DETAILED PROJECT REPORT

VOLUME II - MAIN REPORT

(PART A)

SEMI HIGH SPEED RAIL CORRIDOR
THIRUVANANTHAPURAM TO KASARAGOD

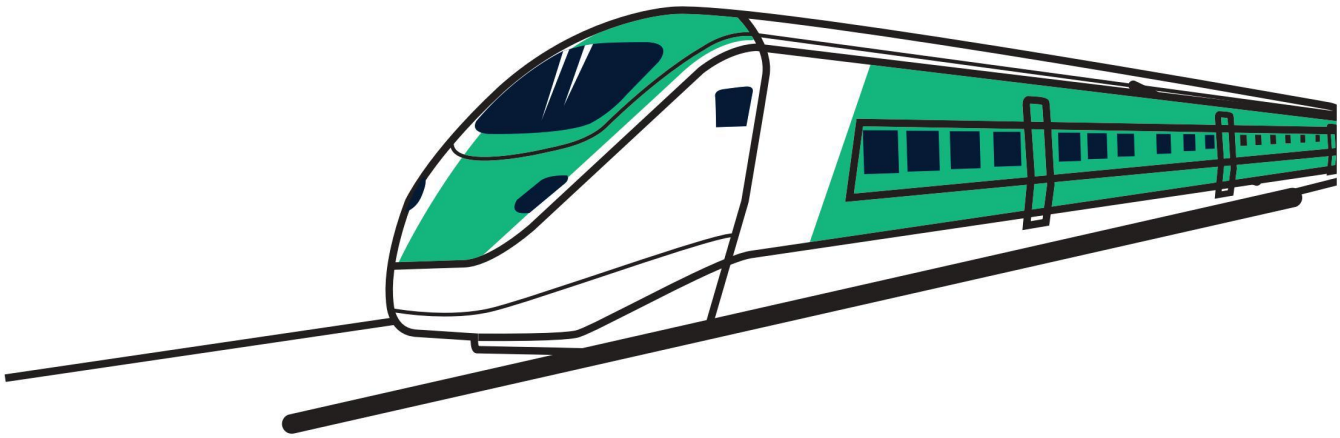
KERALA RAIL DEVELOPMENT CORPORATION LTD

DETAILED PROJECT REPORT

VOLUME II - MAIN REPORT

(PART A)

SEMI HIGH SPEED RAIL CORRIDOR
THIRUVANANTHAPURAM TO KASARAGOD



K-rail

SYSTRA

DETAILED PROJECT REPORT – (VOLUME II: PART A)

DETAILED PROJECT REPORT FOR SILVERLINE (SEMI HIGH SPEED RAIL) FROM THIRUVANANTHAPURAM TO KASARAGOD

IDENTIFICATION TABLE	
Client/Project owner	Kerala Rail Development Corporation Limited (K-RAIL)
Project	SilverLine (Semi High Speed Rail) From Thiruvananthapuram To Kasaragod
Study	Detailed Project Report For SilverLine (Semi High Speed Rail) From Thiruvananthapuram To Kasaragod
Type of document	Detailed Project Report
Date	09-06-2020
File name	KRDCL-FEA-GEN-SYST-REP-00001
Framework	General
Reference number	IN01T18A37
Confidentiality	External
Language	English
Number of pages	289

APPROVAL

Version	Name		Position	Date
2	Production	K-Rail GC Team	-	06-06-2020
	Consolidation	Dr. Amit Kumar Misra	PM Expert	08-06-2020
	Check	M Suyambulingam	Project Director	09-06-2020
	Establishment of liability for the entity			

TABLE OF CONTENTS

VOLUME II: PART C

VOLUME II: PART D

LIST OF TABLES

LIST OF FIGURES

DETAILED PROJECT REPORT

SEMI HIGH SPEED RAIL CORRIDOR
THIRUVANANTHAPURAM TO KASARAGOD

VOLUME II - MAIN REPORT
(PART A)

CHAPTER 1
INTRODUCTION

1 INTRODUCTION

1.1 PROJECT BACKGROUND AND CONCEPTION

1.1.1 The Government of Kerala is in the process of constructing a new double line rail corridor as a Semi High Speed Railway Line, named as SilverLine, between Thiruvananthapuram and Kasaragod cities at the southern and northern ends of the State and the mandate for conducting the technical study has been entrusted to the Kerala Rail Development Corporation Limited (KRDCL, called K-Rail), a Joint Venture Company between the Government of Kerala and the Ministry of Railways.

1.1.2 Kerala is considered the 'Gateway of South India' as has been seen through the history. The State is in the forefront of social and cultural development of India having the highest literacy and human development and empowerment rates among all States in the country. Being a region endowed with ever green forests and above average rainfall, this is one of the States attracting national and international tourists in large numbers. With its huge migrating work force to gulf and other countries, contribution of the State to national economy through remittances received has also been substantial.

Kerala is a State located in the south western part of India, with Arabian sea on the west, Karnataka State in the north and Tamil Nadu on the south and east as bordering States.

It is located between north latitudes 8 deg 18 min and 12 deg 48 min and east longitudes 74 deg 52 min and 72 deg 22 min. It extends over an area of 38,863 sq.kms and has a coast line of 580 km. Its width varies from 120 kms at its maximum and 30 kms at its minimum. Its land area is about 1.18% of that of the country.

1.1.3 India has undergone rapid economic growth in recent years with its GDP growing by 3 times to 2.73 trillion US dollars in the last 10-12 years. Government is taking further steps to encourage investments in India & targeting USD 5 trillion economy by 2024. Along with such growth, demand for transport of people and goods have also grown sharply. Govt of India, in appreciation of this enormous demand, have formulated policies and taken up projects for providing high-speed rail corridors and dedicated freight corridors across the country.

1.1.4 In most of the rail networked countries, globally, all the four major rail transportation systems namely, conventional passenger carrying trains, freight trains, suburban trains and High Speed/Semi High Speed trains are in use. Even though, India has the largest rail network system in the world, our country still does not have any High Speed/ Semi High Speed Railway system running. Asian countries like China, Korea and Japan are already equipped with High Speed Rail Corridor in a big way leaving India far behind. It has helped these countries to economically progress with high GDP rates of growth in the recent years. It is high time, India also took this High-Speed Rail Route of development as it has a vision to develop into leader in South Asia immediately and in the world in the next 30-40 years.

1.1.5 It has a road network of 2.29 lakhs kms of State roads and 1782 Kms of National highways. It has rail route length of 1045 kms over 9 directional routes, most of which are highly saturated. The existing traffic levels at most stretches are excessive and beyond their capacity. As per Kerala Economic Review 2018, the traffic on roads is steadily increasing at a rate of 10 to 11% every year which is significantly high. This has resulted in great increase in road congestion & accidents. There is a widespread realization that the economic and social life in the state of Kerala suffers from slow speed of travel on its existing highways. Capacity augmentation of existing roads is beset with problems relating to limited right of way and land acquisition.

1.1.6 With mostly all governmental functioning located at the State capital Thiruvananthapuram, the southernmost district of the State and industrial and commercial activities spread over the full length and width of the State, the travel need from the northern corner of the State to the south have been growing at an unprecedent rate. The commercial activity centers are mostly at Ernakulam, Thrissur and far north Kozhikode.

1.1.7 The existing road and rail network in the State are not able to meet the fast growing need and speed of travel. The rail corridors are very slow due to speed limitation and require about 10-12 hours to travel from one end to other end of the State. The travel to outside States to Chennai, Mangalore, Mumbai & beyond is also hampered same way affecting the industrial growth and social life of the State badly.

1.1.8 With Capacity augmentation of existing roads beset with problems relating to limited right of way and land acquisition issues, improving the rail sector in the State is best suited solution for facilitating faster travel inside and to outside the State. The State with most of the cities and activity centers located along a linear line extending North to South over 580kms, a dedicated rail corridor is ideally suitable to the State if it provides high speed and more comfortable travel to the large public who have special affinity to travel.

1.1.9 With the above objective, a joint venture agreement between the Ministry of Railways, Government of India & Government of Kerala was executed on 01st September 2016 for infrastructure development of Railways in the State of Kerala and incorporated on 03rd January 2017 by Government of Kerala as Kerala Rail Development Corporation Limited (KRDCL). Following this Government of Kerala advised KRDCL (subsequently renamed K-Rail) to furnish the proposal for 3rd & 4th line from Thiruvananthapuram to Kasaragod vide letter No. Trans-D2/51/2017-Trans dated 04th October 2017. Later, during the meeting of Hon'ble Chief Minister of Kerala with Chairman Railway Board held on 27th October 2017 at Chief Minister's Conference hall, it was jointly decided to propose a project of 3rd & 4th BG line from Thiruvananthapuram – Kasaragod through the JV company K-Rail. Accordingly, a pre-feasibility study was conducted for the above Project

and report submitted to Government of Kerala. The above pre-feasibility report was approved by the Director Board of K-Rail and submitted to Railway board vide letter No.2017.12.30/136/CS dated 30th December 2017 of Government of Kerala. Railway Board examined the pre-feasibility report and advised that more detailed study is required for better appreciation of the proposal. Government of Kerala took approval of Ministry of Railways to build this 3rd & 4th Rail Line as a Stand-alone Semi High Speed Line. Railway Board's Letter No. 2018/Infra/12/33 Dated 16th October 2018 which conveys Minister for Railways agreement to the State's Proposal says "*the matter has been examined. Ministry of Railways supports the proposed Project as a Stand-alone Elevated Rail Corridor of Government of Kerala and will render any technical advice / support as and when required in course of execution of the Project*".

1.1.10 During the 11th Board of Directors meeting of K-Rail held on 18th December 2018, K-Rail was directed to conduct detailed study and to submit a feasibility report of Semi High Speed Rail Corridor from Thiruvananthapuram to Kasaragod. K-Rail has in turn engaged the services of M/s SYSTRA, a consulting and engineering firm and a world leader in transport infrastructure, to prepare a feasibility report first and a Detailed Project Report for the project subsequently. Accordingly, Feasibility Report was prepared by the General Consultancy, M/s SYSTRA and submitted to Government of Kerala on 20th May 2019. The feasibility report was approved by Government of Kerala and submitted to Railway Board vide Government of Kerala Order No. G.O (MS) No.43/2019/Trans dated 26th August 2019. The proposal of K-Rail, now popularly known as K-Rail, was examined in Ministry of Railways and competent authority has accorded "In-Principle Approval" (IPA) for taking up pre-investment activities for the above project vide RB letter No.2019/JV cell/KRDCL/SHSRC dated 17th December 2019. K- Rail directed M/s SYSTRA to further take up preparation of the DPR of for the Project and the same is ready now.

1.1.11 A Special Purpose Vehicle (SPV) in the form of 'Company' shall have to be formed under Kerala Rail Development Corporation Ltd. (K-Rail) for the implementation of Semi High Speed Rail lines from Thiruvananthapuram to Kasaragod, once the project is approved.

1.2 POLICY GUIDELINES FOR THE PROJECT

1.2.1 Government of Kerala's Draft Transport policy 2011 states that *"The quality of transport system in Kerala requires much improvement. Although road transport dominates the transportation scenario in the State, people depend on railways for long haul transport needs. The service levels in train journeys are far from satisfactory. Reservation of seats and berths in general are not available on demand and one has to book tickets more than one month in advance. The public transport system is unreliable, costly and remains very rudimentary".*

1.2.2 Government of India's policy on High Speed Rail, as available in budget documents, States that "*the Ministry of Railways white paper vision 2020 submitted to Indian Parliament by Railway Minister on December 18, 2009 envisages the implementation of regional high speed rail projects to provide services at 250-350 KMPH, and planning for corridors connecting commercial, tourist & pilgrimage hubs. Six corridors have already been identified for technical studies on setting up of high-speed rail corridors: Delhi-Chandigarh-Amritsar, Pune-Mumbai-Ahmadabad, Hyderabad-Dornakal-Vijayawada-Chennai, Howrah-Haldia, Chennai-Bangalore-Coimbatore-Kochi-Thiruvananthapuram, Delhi-Agra-Lucknow-Varanasi-Patna. These high-speed rail corridors will be built as elevated corridors in keeping with the pattern of habitation and the constraint of land. Two new routes were later proposed by Indian Railways, namely Ahmadabad-Dwarka via Rajkot, Jamnagar and other from Rajkot to Veraval via Junagadh. Details are given in the Table 1.1.*

Table 1-1: High Speed Rail Corridors

Sl. No.	Corridor	Total Length (Kms.)	Average Speed Expected (KMPH)
1	Pune-Mumbai-Ahmadabad	650	250
2	Delhi-Agra-Lucknow-Varanasi-Patna	991	300
3	Howrah-Haldia	135	300
4	Hyderabad-Dornakal-Vijayawada-Chennai	679	350
5	Chennai-Bangalore-Coimbatore-Kochi-Thiruvananthapuram	850	300
6	Delhi-Chandigarh-Amritsar	591	350
7	Delhi-Jaipur-Jodhpur	530	300

The Prime Minister of India while addressing the Joint Session of the Parliament on June 9, 2014 mentioned that the Government is committed to launch a Diamond Quadrilateral High Speed Rail Network connecting Chennai, Delhi, Mumbai and Kolkata.

The project of Thiruvananthapuram-Kasaragod Semi High Speed Rail is being proposed under the HSR Policy of Government of India where the route of Chennai-Bangalore-Coimbatore-Kochi-Thiruvananthapuram has been identified at Sl. No. 5 in above Table. As the prevailing traffic in the Thiruvananthapuram-Kasaragod section of Southern Railway is substantially high, and this being the main feeder route for the identified HSR route, this stretch has been selected for the project in first priority. As and when the need is felt, other sections forming part of the identified route in the Government of India's policy will also be prioritized and proposed.

Further in view of existing heavy commuter traffic in trains & roads from the cities and towns which are located in close vicinity to the main commercial cities such as Thiruvananthapuram, Ernakulam, Thrissur, Kozhikode & Kannur and in view of the fact that the population and developments in the State are evenly & linearly distributed, this project also gets importance and priority for consideration under the Government of India's latest policy for taking up new Suburban Rail System on Indian Railways, in Ministry of Railway's letter No. 2016/Proj/Policy Matter/4/2 dated 17.08.2018. Projects which are necessarily required to be integrated with the existing railway system for operational purposes shall be considered by Railways depending upon technical, financial and operational feasibility. In other cases, State Governments should take up independent rail-based transport projects. Since running suburban services on existing tracks adversely affects the capacity of freight trains and long-distance trains, it would not be possible for Railways to use existing infrastructure for the purpose of suburban services. With even distribution of population and growth along the length of the State, it is not only in the interest of the State but also in the best interest of growth and development of the country to have a dedicated passenger train corridor in the form of the Semi High Speed Rail corridor in the State.

1.3 KERALA'S DEMOGRAPHY, TOPOGRAPHY AND NATURAL CHARACTERISTICS

1.3.1 Demographic Profile:

The demographic structure of the study area was derived primarily from 2011 Census records for the Kerala State. Kerala consists of 14 districts spread over an area of 38861 square km. Total population is about 33.4 million with about 48% male and 52% female population. The district-wise population in Kerala is presented in Table 1.2. Out of the total population, Scheduled Caste and Scheduled Tribes are 9.1% and 1.45% respectively. Population density is 860 persons/sq. km with rural and urban population density of 559 and 2097 persons/sq. km respectively which is very high as compared to 382 persons/sq. km at an all India level. Literacy rate is more than 84%. Average family size is 4.25 persons per household. Sex ratio (female to male population) is 1.084.

Table 1-2: District-wise population of Kerala

District	1991	2001	2011	2017*
Kasaragod	1071508	1204078	1307375	1379091
Kannur	2251727	2408956	2523003	2602238
Wayanad	672128	780619	817420	842536
Kozhikode	2619941	2879131	3086293	3226115

District	1991	2001	2011	2017*
Malappuram	3096330	3625471	4112920	4439921
Palakkad	2382235	2617482	2809934	2931854
Thrissur	2737311	2974232	3121200	3225843
Ernakulam	2817236	3105798	3282388	3407138
Idukki	1078066	1129221	1108974	1094573
Kottayam	1828271	1953646	1974551	1982082
Alappuzha	2001217	2109160	2127789	2143334
Pathanamthitta	1188332	1234016	1197412	1175608
Kollam	2407566	2585208	2635375	2655423
Thiruvananthapuram	2946650	3234356	3301427	3347613
Total	29098518	31841374	33406061	34453369

** Source: Vital Statistics Division, DES, Kerala & Census of India*

1.3.2 Socio-Economic Profile:

Kerala has the highest quality of life index in the country, a high literacy rate at 94% against the whole country's literacy rate of 74% and has a good socio–economic status compared to other Indian States. Kerala's health indicators and life expectancy are close to those of developed countries. Achievements in health and education fronts were to a large extent possible through continuous policy initiatives and interventions. Infrastructure investments though limited, has been well utilised resulting in the State having an edge over many other States in social and economic infrastructure.

Kerala is a consumer State and the economy mainly depends on agriculture (coconuts, coir, cash crops such as cashew, pepper, etc). It has limited industries. Tourism has grown to be the fund generating industry. The upcoming of IT and allied industries along with agro-based industries has a lot to look forward in future in terms of economy of the State. The State is willing to exploit the yet-to-be tapped resources and policy perspectives are planned by govts accordingly. The State has witnessed significant migration, especially to the Gulf Cooperation Council (GCC) region and has a huge balance of remittances from the large expatriate community, which contributes more than a fifth of the State's GSDP.

1.3.3 Topography and Natural Characteristics:

The modern societies all over the world have experienced that, as the economy grows there is increased demand for faster travel. Undoubtedly, as evident from the plans to build expressways and high-speed lines in the State and upgrade the existing ones in the past decade, socio-economic growth of the State is being constrained by the State's slow highways and railways. To appreciate the root cause of slow speeds of travel, it is necessary to take a closer look at the unique landforms of Kerala that form the coastal plains and the mid-highlands, which lie between the Western Ghats mountain range in the east and the Arabian Sea in the west. This will also explain why finding a suitable alignment for building a stable and safe high-speed line running almost the full length of the State from Thiruvananthapuram to Kasaragod is a very challenging task. Building this line would require marshalling of engineering skills and innovations to optimise the cost. Despite the costs and the challenges, the fact remains that the State needs a rail-based means of fast travel for its socio-economic growth which has been constrained for the past many years.

Kerala is a narrow stretch of land sandwiched between the Western Ghats in the east and Arabia Sea in the west. Kerala has width from 30 to 120 kms with an average of about 65 kms. The land is traversed by 44 rivers of which 41 have their course towards the Arabian Sea. They take their origin from the Western ghats and flow west until they drain into either the backwaters or flow into the Arabian Sea. The total annual rainfall of the State varies from about 4500 mm in the northern Kerala to about 2000 mm in the south. The rivers are mainly monsoon fed and most of them are perennial in character. The coastal line, which is full of endless sandy beaches, is remarkably straight with mild curves.

Based on the topography, the region can be divided into three zones from west to east;

Zone 1: The rugged topography of the Western ghats mountain and the lower piedmont with an elevation ranging from 600 to 2500 m and 100 to 600m respectively. It occupies about 30% of the State.

Zone 2: The lower piedmont, also referred as mid-highlands, consists of intensely dissected west-east sloping surface of the earth with hillocks and mounds surrounded by wide water courses and lowlands which have been formed by the swiftly flowing rivers and streams. This region occupies nearly 50% of the State's total area. The region's unique landform of alternating sequences of hillocks and mounds surrounded by low grounds with elevation difference ranging from 20m to 80m between the high and low grounds has been formed by rivers, which have been changing their course over the millennia as they dissected the earth, leaving behind the lowlands around the present-day hillocks and mounds. In the rainy season, when the low-lying areas around the hillocks and mounds are waterlogged, the region looks like a sea with a dense cluster of islands when seen from above.

Zone 3: The coastal plains and the backwaters is an area of estuaries, lagoons, alluvial plains, and beach ridges and dunes fringing the coast. It covers about 20% of the area of the State with elevation ranging between 0m and 15m. It has a maximum width of about 25 km near Alappuzha. The coastal plains are full of backwaters, which are a chain of brackish lagoons and shallow lakes lying parallel to the Arabian Sea coast. The network of the backwaters includes five large lakes linked by canals, both manmade and natural, fed by 38 rivers, and extending more than half the length of Kerala State. The backwaters have been formed by the action of waves and shore currents creating low barrier islands across the mouths of the many rivers flowing down from the Western Ghats range. Vembanad lagoon is the largest waterbody extending about 183 km parallel to the coast from north of Varkala to Azhikode in the north of Kochi with six major rivers flowing into it. Kuttanad, south end of the Vembanad lagoon is a deltaic formation of mainly four rivers Achankovil, Pampa, Manimala, and Meenachil. The second largest lagoon is the Ashtamudi at Kollam, which has a length of 16 km and a total width of 15 km.

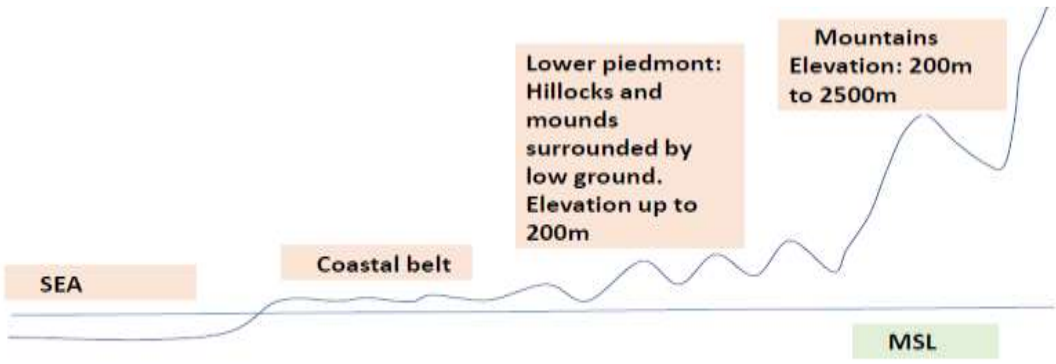


Figure 1-1: The topographic divisions of the State of Kerala

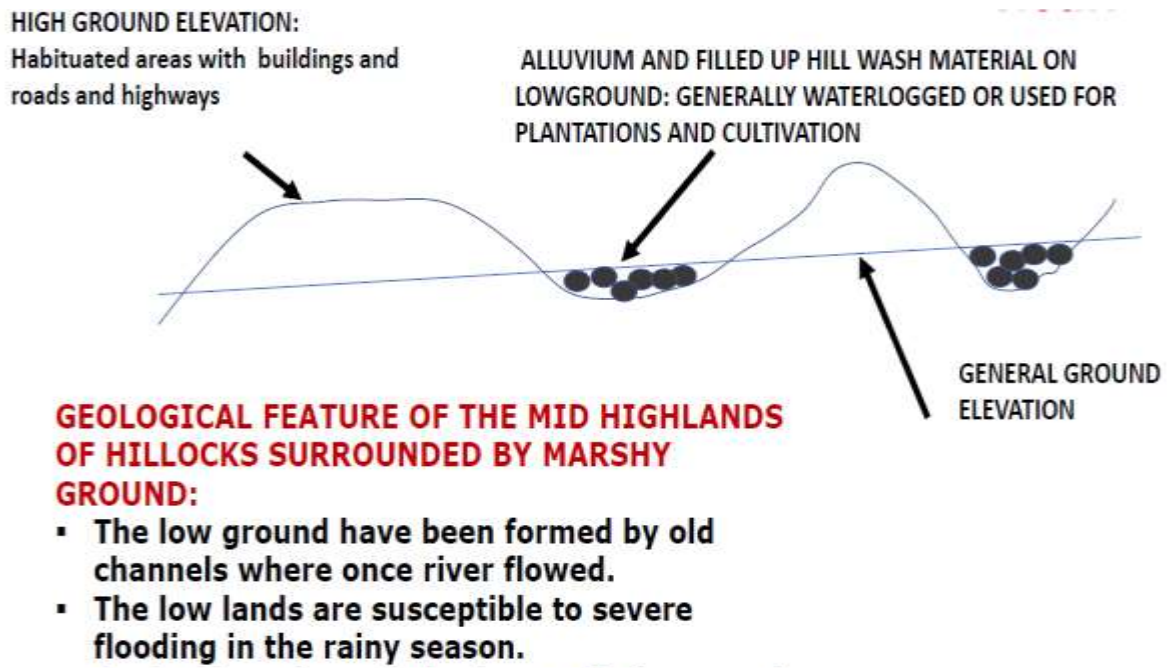


Figure 1-2: The unique landform of the mid-highland region of Kerala

The result of the two landforms between the Arabian Sea and mountains of the Western ghats is that in the rainy season large areas are occupied by water bodies and several other areas with undulating terrain are inundated with water. So, only a small proportion of the land is free from water and inundation round the year. People in these regions live in scattered patches of high ground. The larger cities like Thiruvananthapuram, Kollam, Kannur, Kottayam, Chengannur, and Thrissur have come up where there are large areas of high ground. Kochi/Ernakulam is a rare example of a large city built on low ground near the sea coast (with houses built on pile foundations), like Venice in Europe on the Adriatic Sea. There are very few large villages to be found in the mid-highlands, and hamlets are scattered all over wherever there is high ground to build houses that would be safe from the flood waters. Between Kozhikode and Kasaragod, the midland topography of alternating mounds and waterlogged low ground is more pronounced. The towns and cities in the midlands are small and more dispersed. For example, in district Malappuram, there are several cities and towns such as Malappuram, Kottakal, Manjeri, Tirur, Ponnani, Nilambur, and Valanchery, but none has a very large population. By contrast, the coastal belt has larger cities and there is less scattering of urban population.

These unique landforms, which together cover about 70% of the State's land area, have resulted in slow speed of surface transport. The highways basically find high ground by connection patches of high ground in a sequence. The result is that the roads are highly

curved and there are steep gradients as the roads move up and down between the alternating low and high ground.

The railway lines have been laid in a slightly different manner: basically, closer to the low ground as they traverse the region on cuttings in the slopes of the hillocks and mounds and on high embankments in low lying flats.

Both the railway lines and roads are badly affected in the rainy season because of continuous rains and waterlogging in the region. Occasional very heavy floods, like those of 2017 and 2018 also hold the State to ransom when the whole traffic infrastructure fails. Speed is relatively better in portions where the railway line and roads are situated closer to the sea in the flat terrain of the narrow coastal belt.

These landforms and the dispersed population present a serious challenge in building a high-speed railway line. Additionally, in the coastal plains the main problem is of low bearing capacity which is encountered almost everywhere. The soils of the coastal plains are very deep with sandy texture. Rock, and stiff soils are usually encountered at more than 30 to 50 m depth. The sand content of the soil near the surface, ranges from 80% and clay up to 15%. Even though these soils have high water table, the water holding capacity is poor due to the predominance of sand. In the backwaters, the content of silt and clay is relatively higher. In the paddy field of Kuttanad, sandy clay loam to clay is the predominant soil. On the other hand, in the midland's undulating terrain with waterlogged regions surrounding the hillocks and mounds, the main problem is of instability of cuttings in laterite soil/rock which is the dominant material on the surface at up to several meter depth. Further, because, high embankments would not be stable in the lowlands which are prone to water logging and flooding, the high-speed line would have to be carried over the lowlands between the hillocks on high viaducts. Alternatively, the line would have to be carried in tunnels laid at shallow depth below the ground by avoiding both the hillocks and the lowlands.

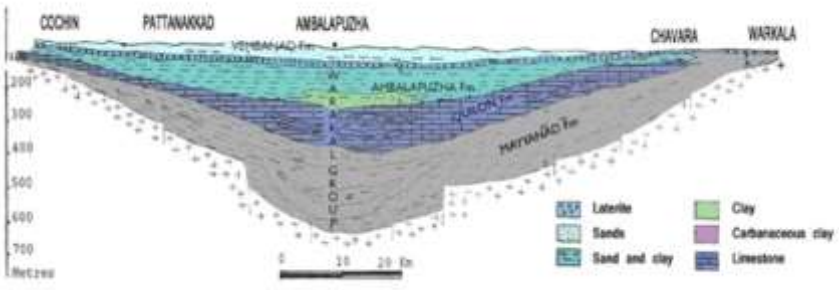


Figure 1-3: CS of the ground along the coastal plains from Varkala to Kochi

1.3.4 Ecology Sensitive Area

The proposed SilverLine corridor is not in a nationally or Internationally recognized area for nature conservation. However, the Kerala State is known for its conservation and there are 7 national parks and 15 wildlife sanctuaries in the state. The alignment lay out has been very wise as it doesn`t covers any protected areas like National Parks, Wildlife Sanctuary and Biosphere Reserves as per Wildlife Protection Act, 1972 along the both side of the alignment (10 km wider) of the proposed site or proposed station areas. No area or village along the alignment or proposed station falls under Western Ghats Notification, 2015. Hence, no ecologically sensitive areas were observed during our field survey and as per our secondary data review as per Kasturirangan and Report as per Western Ghat Ecology Expert Panel (WGEEP). The proposed SilverLine activity is far away from such ecological sensitive areas.

1.4 EXISTING ROAD, RAIL, AIR, WATERWAY INFRA IN KERALA

1.4.1 Road:-

Infrastructure on the transport sector for the intercity travel in the state is mostly by road, and rail. Kerala has 2.29 lakh kilometres of roads. Kerala has 11 National Highways which run for about 1782 Kms. However, conditions of roads in Kerala have been a major source of concern due to undulating planes and climatic factors. The poor condition of the roads and large number of road vehicles causes increased road accidents.

Figure 1-4: Kerala Road Map

Table 1-3: List of National Highway in Kerala

Sl. No.	New NH No	Route	Length (Km.)
1	NH 66	Thalappady- Kaliyikkavila	669.437
2	NH 544	Walayar- Edappally,Ernakulam	168.14
3	NH 85	Bodimettu - Kundanoor	167.593
4	NH 183	Kollam- Theni (Tamil Nadu Border)	216.3
5	NH 183A	Bharanikkavu - Pathanamthitta (via) Vandiperiyar	116.8

Sl. No.	New NH No	Route	Length (Km.)
6	NH 185	Adimaly - Painavu (via) Kumili	96
7	NH 744	Kollam- Kazhuthuruthy	81.28
8	NH 766	Kozhikode- Muthanga Kerala– Karnataka Border	117.6
9	NH 966	Kozhikode -Palakkad	125.3
10	NH 966A	Vallarpadam - Kalamassery	17.2
11	NH 966B	Wellington Island - Kundanoor	5.92
		Total	**1782 km**

Source: Kerala Economic Review 2018

There are 72 State Highways in Kerala. Of them, MC Road (Main-Central Road), proposed Hill Highway (Kerala) and Main Eastern Highway are the longest. The respective State Highway number is displayed on the top of all milestones (black in colour in green background) on the respective roads. These State highways are also constrained by slow speeds and sharp curves and steep gradients making them less favourable and more accident prone, particularly in adverse weather conditions.

NHAI has been having problems in widening selected national highways on account of high cost of land and projects sanctioned years back are yet to be ready. Road developers have also been having problems in smoothening curves and gradients leading to slower speeds and holding up of traffic at several locations. Road movements between cities like Thiruvananthapuram and Kochi and Kochi and Kozhikode, the main centres of economic activity in the State have been taking an enormous run time of 6 to 7 hours for the 200 odd kms inter-distances involved.

1.4.1.1 Slow growth of national Highway infrastructure and status of Highways in Kerala

As per Kerala State Planning Board Economic Review 2018, the NH length is 1782 kms., of which many stretches are under various development stages by the National Highways Authority of India (NHAI). In the case of National Highways, only about 12 per cent of the roads have four lane capacities while the remaining roads have only two lanes or intermediate lane capacity. Bulk of the inter-city and inter-state traffic is carried out by the National and State Highways which constitutes only 8 per cent of the total network. Considering the demand supply gap, there is a huge need for up gradation of existing road network.

The total State road length which includes classified and non-classified roads as stipulated by Indian Road Congress and its growth in Kerala during last 3 years can be observed in table 1.4 below,

Table 1-4: Growth of Highways in Kerala

S. No.	Year	Length of Road (Kms)	Density (Km/100 sq km)	length of Road per lakh population (Kms)	% Annual growth in road length
1	2015-16	205,545	Top of Form 528.8	615.5	Bottom of Form
2	2016-17	218,942 Bottom of Form	554.35	655.7	7%
3	2017-18	229,349	590	686.55	5%

Source: Kerala Economic Review 2018

As per Kerala State Planning Board Economic Review 2018, Kerala has 120.42 lakh registered motor vehicles as on March, 2018. About 2774 vehicles are being added to vehicle population every day. For the last two decades it has experienced a compounded annual growth rate of above 10 percent. The number of vehicles per 1,000 population as on March 2018 is 361 in Kerala. According to world development indicators (2015), number of vehicles per 1,000 population in India is 18, China 47 and United States 507. The growth of vehicle population in Kerala is eight percent over the previous year. The growth of Motor Vehicles during the last ten years is shown below in Figure 1.5.

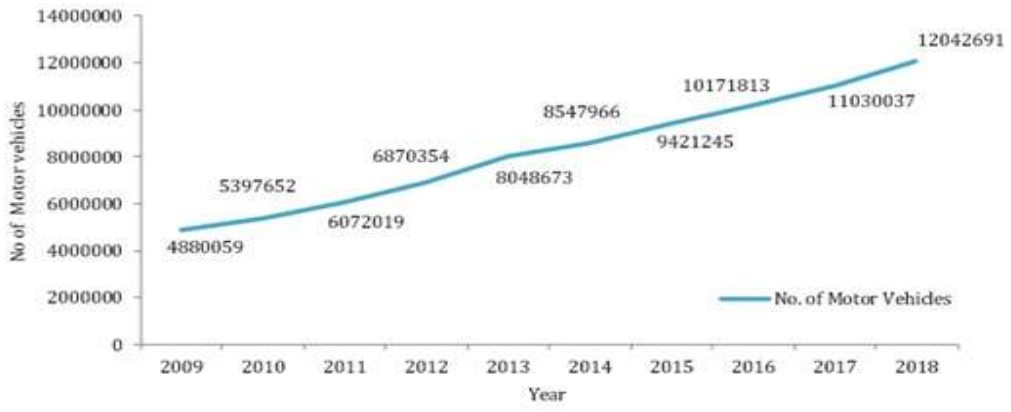


Figure 1-5: Vehicle Registration Growth

Source: Kerala Economic Review 2018

With above, it is clearly observed that population of motor vehicles are increasing every year at high rate whereas on the other hand road capacity is not increasing in the same proportion. This results in more accidents. The increasing trend of traffic accidents is a matter of big concern for Kerala. The analysis from 2010 onwards shows that there are

regular increase in the number of accidents from 35,633 in 2010 to 38,734 in 2018. These number of accidents is considered as very high compared to other states. The bigger states like Uttar Pradesh, Gujarat and Rajasthan report far less number of accidents compared to Kerala.

Most of the roads in the State do not have adequate width to address the existing level of traffic, only one fourth of the roads have either two lanes or four lane capacity while most of the other roads have single lane or intermediate lane capacity. In the case of National Highways also, only about 12 per cent of the roads have four lane capacities while the remaining roads have only two lanes or intermediate lane capacity. Bulk of the inter-city and inter-state traffic is carried out by the National and State Highways which constitutes only 8 per cent of the total network. Considering the demand supply gap, there is a huge need for up gradation of existing road network. The existing road network has to undergo a qualitative improvement with the aim to reduce traffic congestion and delay, easy access to destinations and reduction in accident risks. Most of the PWD roads have to undergo massive upgradation with widening duly incorporating road safety features.

Reference: *Economic Review 2010-2018, Motor Vehicle Department,* **Department** of Economics and Statistics, Kerala

Source : http://www.kerenvis.nic.in/Database/RoadNetworkKerala_2284.aspx

1.4.2 Rail:

As per system map of southern railway of 2018, total route length of railways in Kerala is 1045 route kms spiced with 181 stations. The total rail network in Kerala accounts for 1.55% of total Indian Railway's route length of 67,368 kms as on 2017. The average route kms per lakh population of Kerala is 3.16 kms which is very less compared to average route km per lakh population of India is 5.56 kms. There are six inter–State railway stations, with five towards Tamil Nadu and one towards Karnataka. Kerala's major railway stations are Alappuzha, Aluva, Chengannur, Ernakulam Junction (Kochi), Ernakulam North (Kochi), Kannur, Kasaragod, Kayamkulam Junction, Kollam Junction, Kottayam, Kozhikode, Palakkad Junction, Shoranur Junction, Thalasseri, Thrissur, Thiruvalla, Vadakara and Thiruvananthapuram Central. Passenger earnings in most of these stations are substantially high as the level of intra-State (inside) and inter-state (outside) express and passenger train traffic is very high compared to other States in the region. The Thiruvananthapuram and Palakkad division of Southern Railway operates the railway network throughout the State. In-spite of the fact that these routes and the two divisions in Kerala are substantially contributing to the earnings of the Southern Railway growth of railways and improvement in railway's capacity to handle the growing rail traffic are hampered by some serious factors which are discussed below. States rail map is shown in Figure no 1.6.

Figure 1-6: Kerala Railway Network Map

1.4.2.1 High Utilization of the Existing Rail Transport System

Table 1.5 shows the present utilization of the existing rail corridor between Thiruvananthapuram and Kasaragod. It indicates that the existing IR corridors are already saturated.

Table 1-5: Utilization of existing rail corridor

Section	Length (km)	Traction and system of working	Year	% utilization
Trivandrum-Shoranur	327	Double line Electric and absolute block system	2018-19	**110%** (Ernakulam-Kottayam _ Kayamkulam section)
Shoranur - Kasaragod DL	261	Double line Electric and absolute block system	2018-19	**80%** (Shoranur - Kozhikkode section)

Source: Working time table

In spite of having 1045 kms of route length of rail, over 9 routes and 181 stations, due to inadequate infrastructure the traffic needs of the population could not be met with by the

railways. Railways own infrastructural projects such as doubling in various sectors have also been taking several years for the same reasons as occurring in National Highway sector.

.

1.4.2.2 Technical Difficulties in Removing the Existing Permanent Speed Restrictions on Rail

The difficult terrain conditions and mostly inclement weather have imposed serious rail speed restrictions which hamper the fast and smooth travel across the State. There are 65 permanent speed restrictions in the TVC – SRR section and 35 in the SRR – KGQ section. These are mostly on account of the existing sharp curves and steep gradients, yielding formations and deep cuttings. These cannot be removed without providing major diversions involving long detours and heavy structures like tunnels and viaducts which will involve huge land acquisitions and heavy expenditure and in most of the cases they are also not practical to execute. Hence these permanent speed restrictions will continue to exist and will not allow higher speed operations on the existing corridor which the Railways have planned several times and left due to inherent problems as explained above. Even a new corridor, if planned parallel to the existing railway one will have the same deficiency as it would also be travelling the same terrain. Average speed of express trains in the existing corridor between Thiruvananthapuram and Tirur is less than 50 kmph and that is the next section is slightly better.

1.4.2.3 Inadequate Platform and Terminal Facilities at Thiruvananthapuram and Other Stations

Thiruvananthapuram and Ernakulam are the terminal station yards for both Mail/Express and passenger trains in Kerala. As the existing platforms are fully occupied normally introduction of new trains has been found extremely difficult. Sporadic development of ancillary terminals such as Kochuveli, etc could not solve this problem as the State's demand is so high such miniscule developments are always behind the growth of the State produced. This has been brought out in the RRTS study conducted by MRVC at Thiruvananthapuram. The adjacent line from the existing platform No's. 5 are the pit lines 6, 7, 8, 9 and 10. As the Thiruvananthapuram Yard is land locked between two main roads on either side, there is no scope for providing adequate new platforms/ pit lines. Thiruvananthapuram being the capital city requires trains to reach at peak hours in the morning and evening. Hence most of the mail/ express trains and passenger trains are planned to reach the city at these peak hours. This peak hour rush, coupled with the nearly saturated track utilization, makes it difficult for new trains to be introduced on the existing rail corridor. Similar situation exists at Ernakulam, Kozhikode and other terminal stations in the State.

1.4.2.4 Inadequate Capacity of Stations

Though there are large number of stations in both divisions which are very popular and high earning, facilities could not be provided due to land constraints. Platforms are inadequate to permit more train services. This imposes the biggest difficulty to the railways to introduce more services.

1.4.3 Air Traffic-Airways in Kerala

The four international airports in Kerala are located in Kannur, Kozhikode, Kochi and Thiruvananthapuram. The airports in Kochi, Thiruvananthapuram and Kozhikode have witnessed a dramatic growth in passenger traffic this year as compared to last year figures. The number of new services from these airports have also increased considerably. For the record, in total, the three airports saw a passenger traffic of 1.5 crore during the last fiscal.

In terms of passenger movement and travel business, the Cochin International Airport recorded the highest growth among the three major air ports. The facility saw a passenger traffic of 89.4 Lakhs during the 2016-17 compared to the 77.5 Lakhs passengers during the previous year. There was an increase of 7.7% in the number of international travellers and 26% rise in domestic passenger traffic.

The Thiruvananthapuram international airport recorded a growth of 12.4 percent in passenger traffic during the last financial year. Growth was recorded in both international domestic passengers, which stood at 15.8 lakhs and 23 lakhs respectively, and 38.8 lakhs in total. Notably, the passenger traffic has grown significantly despite the partial closure of the runway for three months to fix wear and tear.

Table 1-6: Popular Destinations and flights from Kochi

Sl No	Destination	Number of flights per month
1	Bengaluru	192
2	New Delhi	158
3	Mumbai	145
4	Hyderabad	108
5	Dubai	102
6	Chennai	101
7	Abu Dhabi	68
8	Dubai(Sharjah)	52
9	Muscat	51
10	Kuala Lumpur	44
11	Thiruvananthapuram	39
12	Kuwait City	35

Sl No	Destination	Number of flights per month
13	Kannur	34
14	Doha	29
15	Ahmedabad	19
16	Pune	19
17	Bahrain Island	17
18	Agatti Island	17
19	Male	17
20	Kozhikode	17
21	Hubli/Dharwad	17
22	Colombo	16

Table 1-7: Popular Destinations and flights from Thiruvananthapuram

Sl No	Destination	Number of flights per month
1	Bengaluru	108
2	New Delhi	53
3	Mumbai	41
4	Hyderabad	34
5	Dubai	45
6	Chennai	71
7	Abu Dhabi	42
8	Dubai(Sharjah)	60
9	Muscat	36
10	Kuwait City	15
11	Kannur	36
12	Doha	9
13	Bahrain Island	17
14	Male	31
15	Kozhikode	14
16	Colombo	16
17	Coimbatore	4
18	Kochi	41
19	Singapore	10

Table 1-8: Popular Destinations and flights from Kozhikode

Sl No	Destination	Number of flights per month
1	Bengaluru	17
2	New Delhi	5
3	Mumbai	34
4	Dubai	79
5	Chennai	28
6	Abu Dhabi	51
7	Dubai(Sharjah)	53
8	Muscat	56
9	Thiruvananthapuram	14
10	Kuwait City	3
11	Kannur	10
12	Doha	20
13	Bahrain Island	34
14	Kozhikode	17
15	Jeddah	17
16	Riyadh	27
17	Dammam	8
18	Al Ain	5
19	Ras Al Khaimah	4
20	Salalah	2
21	Kochi	17

Table 1-9: Popular Destinations and flights from Kannur

Sl No	Destination	Number of flights per month
1	Bengaluru	15
2	New Delhi	10
3	Mumbai	17
4	Hyderabad	29
5	Dubai	17
6	Chennai	17
7	Abu Dhabi	25
8	Dubai(Sharjah)	17
9	Muscat	24

Sl No	Destination	Number of flights per month
10	Thiruvananthapuram	36
11	Kuwait City	1
12	Kannur	34
13	Doha	9
14	Bahrain Island	5
15	Kozhikode	2
16	Hubli/Dharwad	17
17	Kochi	34
18	Goa	17
19	Dammam	9
20	Riyadh	4

As mentioned earlier, air traffic growth is akin to economic growth of the country and its international exposure. It also indicates high rate traffic is on the increase. This will be a positive factor as for short distance intra-State traffic, while the demand will be high, par or equal cost of travel by SilverLine will bring in good and economical migration of traffic from air to trains.

However the intercity travel between the three airports (Kochi, Thiruvananthapuram and Kozhikode) account to only 4% of the total trips produced to any of the three airports. Thus, the share of air trips for the intercity travel can be considered as negligible. Though the inter-state and international traffic from these airports have been on the rise along with the economic growth of the State and the country, the intra-State air traffic has not been showing much growth mainly for the reasons of the need for long check-in hours and security delays apart from the high cost of air travel in the local sectors.

1.4.4 In-Land waterways-Water way Navigation in Kerala

Waterways have always been an important mode of transport in Kerala. The total length of navigable water way route in Kerala is 1,900 Kms. The 41 West-flowing rivers together with the backwaters are an integrated part of the inland navigation system in Kerala. The State's inland waterways pass through highly populated regions - the West Coast Canal, for instance. The majority of those inhabiting the region were engaged in traditional industries such as coir, cashew, brick-making and fishing. Any attempt to develop the inland waterways will favorably impact the well-being of these people. On the main West Coast Canal between Kollam and Kottapuram, the Kochi Edapallikota (120 km) stretch was opened for cargo movement during November 1994 consequent to improvement works carried out by IWAI. Capital dredging for widening and deepening of canal between Kochi and Kollam was started in first phase during 1997-98. Project for providing and maintaining 24 hrs navigational aids by way of buoys and lights had been completed

during 2007-08 and now the entire waterway has the facility for 24 hrs navigation which was maintained during 2008-09.

As an alternative mode of transport, waterways help in dealing with Air pollution and Road Accidents. To divert a share of goods and passenger traffic to the waterway, agencies in the field are toying with the idea of linking the Cochin International Airport and the Kochi port, which are 17.2-km apart. This will be a first of its kind endeavor in the country. A few water bodies on the route will have to be widened and dredged for the project to materialize. Another proposal is to connect navigable canals in Kochi with the waterway.

However the project of identifying and providing inland waterways is a herculean task as it involves huge acquisition of land and involvement of cost. It is expected that this project would take enormous time. Even at the end of the day, if and when completed, this will facilitate only goods traffic as speeds will be low.

1.4.5 Semi High-Speed Railways In Kerala

The existing railway network and highways in the State are not amenable to faster travel. Average speed on road and by trains is among the lowest of all regions of the country. The average speed of journey by rail and road in the State is about 30% to 40% lower than in the neighbouring States. The journey become even slower in the rainy seasons with high intensity of rainfall in the months of May to August because of deterioration in the condition of the roads and railway lines. Because of the adverse terrain, there is little scope of economically raising speed of trains on the existing railway line in the corridor. Widening of the existing highways in the State has brought about some improvement in the speed of travel. Plans to build a six-lane expressway have been going on since a long time. Speed of travel on the railway tracks has stagnated for the past many years because of massive requirement of land acquisition for such a highway. There is a widespread realization that the economic and social life in the State of Kerala suffers from slow speed of travel on its existing highways and railways. With the above in mind, the Government has decided to build the Thiruvananthapuram - Kasaragod corridor as a Semi high-speed rail (SHSR) line, covering the coastal region which is the most densely populated region of the State. However, the technical feasibility and financial viability of this SHSR line is largely dependent on the following three quite distinctive factors;

- Cost of construction of the line could be high because of the uniquely unfavourable terrain and ground conditions in the corridor. This would mean that a large part of the line may have to be carried in tunnels, viaducts/bridges and high cuttings/embankments. Besides, the cost of land acquisition and compensations for displacement and rehabilitation would also be high because of high cost of land in the coastal plains and the mid-highlands through which the line would pass.
- The other challenge was posed by what is termed as “urban sprawl” in the State. In the State of Kerala it manifests itself in the form of numerous small

towns and cities all over the State. So, it would be a challenge to locate the stations on the SHSR line.

- The third challenge comes from the fact that availability of funds for the project and also the construction materials are always issues of concern in the State and the same have to be met with clear foresight and vision.

1.5 REVIEW OF HIGH-SPEED AND SEMI HIGH-SPEED RAIL DEVELOPMENTS IN ABROAD AND INDIA

1.5.1 High Speed Rail all over the world

The Italian ETR 200 (Figure 1.1) in 1939 was the first high speed service train. It achieved the world mean speed record in 1939, reaching 203 km/h near Milan.

Figure 1-7: Italian ETR 200

Concept of High-Speed train has started developing throughout the world after the world war-II. Japan has taken a lead in this field followed by several European Countries viz France, Germany, Sweden etc.

During last 50 years enormous advancement has taken place in this field. Several historical milestones have been achieved by various countries. It will be interesting to see the evolution of speed record in Railways since its inception in Table 1.10

Table 1-10: Speed record in Railways

YEAR	SPEED (km/h)	TRACTION	LOCOMOTIVE / TRAIN
1804	8	Steam	Trevithick's Locomotive
1825	24	Steam	Stephenson's Locomotive no. 1
1830	48	Steam	Stephenson's Rocket
1848	96.5	Steam	Boston & Maine "Antelope"
1901	162	Electric	Seimens & Halske Railcar
1903	206.7	Electric	Seimens & Halske Railcar
1903	210.2	Electric	AEG Railcar
1938	202.8	Steam	A4#4468 "Mallard"
1955	326	Electric	Alstom Electric Loco CC7107
1955	331	Electric	Alstom Electric Loco BB9004
1981	371	Electric	TGV-PSE 16
1981	380.4	Electric	TGV-PSE 16
1988	387	Electric	ICE-V BR-410-001
1988	406.9	Electric	ICE-V BR-410-001
1988	408.4	Electric	TGV-PSE 88
1990	515.3	Electric	TGV-A (Atlantique) 325
2007	574.8	Electric	TGV V150 (LGV Est) 4402

Source: Construction & Maintenance of High Speed Railway, Indian Railway Institute of Civil Engineering, Pune.

The chronological development of High-Speed Rail in various countries is described as under,

- The first HSR line was **Japan's** Shinkansen service between Tokyo and Osaka, which opened in 1964 with a maximum speed of 130 mph (210 km/h). It is a dedicated HSR system, meaning that it was built especially for high-speed trains and only high-speed trains operate on it.
- **France** took the next big step for shared-use HSR with the introduction of the Train à Grande Vitesse (TGV) program in 1981. The first TGV line, running between Paris and Lyon, was a dedicated line with shared-use segments in urban areas. It proved that high-speed rail could attract a large share of the airline passengers in medium-distance markets.
- **Germany's** high-speed train system, the InterCity Express (ICE), began operation in 1992. Germany used a coordinated program of improvements in infrastructure, rolling stock, and service, upgrading much of the mainline track network for speeds of 125 mph (200 km/h). This allowed ICE trains to efficiently share tracks with other trains and enabled Germany to expand its HSR network quickly and cost effectively.
- The only HSR system operating in the **United States** today is on Amtrak's Northeast Corridor. In 1968, the corridor's private sector owner introduced the Metroliner service, consisting of track improvements and new higher-speed rolling

stock. The Metroliner's initial top speed was approximately 110 mph and operating speeds eventually reached approximately 125 mph (200 km/h).

The pace of construction of High-Speed lines is increasing day by day and several new countries are joining the high-speed club. Length of high-speed rail routes and their speeds in various countries is given in the Table 1.11

Table 1-11: Length & Speed of HSR in various countries

Country	Total Network Length in Kms	Test run Speed record in Kmph	Average Speed of Fastest Scheduled Train in Kmph
Belgium	214	347	237
China	19369	394	313
France	2036	574	272
Germany	1334	406	226
Italy	923	368	178
Japan	2664	443	256
Netherlands	1200	336	140
South Korea	819	355	200
Spain	3100	404	236
Switzerland	79	280	140
Taiwan	336	315	245
Turkey	1420	303	140
United Kingdom	1377	335	219
Total	**34871**		

Source: Construction & Maintenance of High Speed Railway, Indian Railway Institute of Civil Engineering, Pune.

Majority of high speed Railway lines under construction are in China, France, Germany and Japan. In recent past USA and UK and India have taken definitive steps to create high speed rail corridors. Thus, in future more corridors of high speed rail are expected from these countries apart from China and Japan. Table 1.12 below, mentions/provides the length of high speed rail line under construction in various countries.

Table 1-12: Length of HSR Lines Under Construction in various countries

Country	Length under Operation (KM)	Length under construction (km)
Austria	292	210
Belgium	209	0
China	19369.8	16280
Denmark	5	60
France	2036	757
Germany	1334	428
Italy	923	125
Japan	2664	782
Netherlands	120	0
Poland	85	322
Russia	1496	0
South Korea	819	585
Spain	3100	1800
Switzerland	80	57
Taiwan	339	9
Turkey	1420	1506
UK	1377	0
USA	362	483

Source: Construction & Maintenance of High Speed Railway, Indian Railway Institute of Civil Engineering, Pune.

Thus a total of 23,404 km of high speed rail length is under construction out of which 2/3rd is in China.

The High-Speed Rail development journey in various countries are mentioned below,

Japan

The first Shinkansen trains, the 0 Series Shinkansen, built by **Kawasaki Heavy Industries** in 1964. The first Shinkansen trains ran at speeds of up to 210 km/h (130 mph), soon after increased to 220 km/h (140 mph).

The first Bullet trains had 12 cars; later versions have up to 16, and there are double-deck trains too, to increase the capacity.

After three years, more than **100 million passengers** had used the trains, and the **first billion** was passed in 1976. Later, the Shinkansen system has grown to a 2459 km network.

the Tokaido Shinkansen still is the world's busiest high-speed rail line. Up to ten trains per hour with 16 cars each (Net seat capacity of the train: 1300) run in each direction with a minimum of 3 minutes between trains.

China

In the middle of 1990s', China's trains used to travel at top speed of around 60 km/h. From 1997 to 2007, the speed of China's railways increased six times. In 1998, China started the construction of its first high speed rail, the Qinhuangdao-Shenyang Passenger Dedicated line (Qinshen PDL), this PDL was opened in 2003, with designed speed of 200km/h. The development of the domestic technology was not that successful as was initially expected. Then China has decided to import HSR trains and technology from Europe and Japan, which are currently known as CRH (China Railway High speed) Trains. However, most of the train-sets are manufactured by Chinese companies as technology transfer agreements are contracted as part of the deals with foreign companies.

In April 2007, China launched the sixth "speed up" campaigns. CRH service firstly opened at some 6,003 km of tracks. 52 CRH train-sets (CRH1, CRH2 and CRH5) were put into operational service as 280 train numbers.

China has opened its 15th High speed rail, the Huhang (Shanghai-Hangzhou) PDL on 26 October, 2010 which uses the CRH380A train-set manufactured by CSR Sifang. It covers the 200-km distance in only 45 minutes, reducing the travelling time from 78 minutes at an average speed of 350 KMPH.

	**Taiwan High Speed Rail (THSR)** Taiwan High Speed Rail (THSR) is a high-speed rail network is approximately 345 km (214 mi) long and runs from Taipei to Kaohsiung. THSR began service on January 5, 2007. The project had a total cost of US$18 billion and is one of the largest privately-managed and funded transport schemes to date. THSR's technology is based mainly on Japan's Shinkansen system, mixed with European standards and system components. The Taiwan High Speed 700T train is a variant of the 700 Series Shinkansen and was built by a consortium of Japanese rolling stock builders, most notably Kawasaki Heavy Industries. Trains with a service top speed of 300 km/h (186 mph).
	**South Korea** South Korean KTX high-speed rail, which runs on a dedicated line, became operational in April 2004. The maximum speed of the KTX, which derives its technology directly from France's Alstom TGV, is 300 km/h. Daily ridership is now in the range of **85,000 passengers.** Diversions from other modes show wide variability, according to customer surveys. KTX enticed 56% from existing rail services, 17% from air, 15% from express buses, and 12% from highways.
	**France** SNCF operates almost all of France's railway system, including the TGV (Train à Grande Vitesse, meaning "High-Speed Train"), In the 1970s; SNCF began the TGV high speed train program with the intention of creating the world's fastest railway network. It came to fruition in 1981, when the first TGV service, from Paris to Lyon, was inaugurated. Today, SNCF operates more than 1,100 miles of designated high-speed track that accommodates more than 800 high-speed trains per day. SNCF's TGV trains carry more than 100 million passengers a year. SNCF's TGV has set many world speed records, the most recent on April 3, 2007, when a new version of the TGV dubbed the V150 with larger wheels than the usual TGV, was able to cover more ground with each rotation and had a stronger 25,000 hp (18,600 kW) engine, broke the world

	speed record for conventional rail trains, reaching 574.8 km/h (357.2 mph). SNCF has a remarkable safety record. After nearly 30-years in operation, SNCF's TGV system has never experienced a fatal accident.
	**United Kingdom** The Channel Tunnel Rail Link (CTRL), now known as High Speed 1 (HS1), was the first new mainline railway to be built in the UK for a century and was constructed by London and Continental Railways. After a lengthy process of route selection and public enquiries in the second half of the 1990s, work got under way on Section 1 from the Channel Tunnel to west of the Medway in 1998 and the line opened in 2003. Section 2, continuing the line to London St Pancras, started soon after Section 1 and was opened to the public on 14 November 2007. The construction of High Speed 1 also permitted the introduction of a new domestic high-speed service when in 2009 Southeastern launched its high-speed route between London St Pancras and Ashford International. Operated with a fleet of British Rail Class 395 trains, the service reaches a top speed of 140 mph (225 km/h). Southeastern High-Speed is currently the only British domestic high-speed service allowed to run above 125 mph (201 km/h)
	**Germany ICE-2 (1996)** Germany has 4 HSR routes covering almost 900 KMs with 3 further routes planned. ICE-2 280 KMPH (1996) ƒ ICE-3 350 KMPH (under trial).

ITALY

Italy opened the first high-speed rail route, the Direttissima, which from 1978 connected Rome with Florence (254 km/158 mi). The maximum speed of the Italian line was 250 km/h (160 mph), giving an endto-end journey time of just over 90 minutes with an average speed of 200 km/h (120 mph). Since then, Italy's high speed network has grown substantially. Several types of high-speed trains, belonging to three major families, carry out the service:

(1) ETR 500 (Elettro Treno 500 - non-tilting),

Speeds: 362 km/h

(2) ETR 600 ETR 610 Frecciargento (Tilting)

Speed: 250 km/h

(3) ETR 480 (tilting for other services used as the Tbiz a business class-only train.

Speed: 250 km/h

(4) ETR 450, ETR 460, ETR 485 (Tilting)

Speed: 250 km/h

(5) ETR 470 (Tilting)

Speed: 250 km/h

Belgium

Belgium's rail network is served by four high-speed train operators: Thalys, Eurostar, ICE and TGV trains.

The HSL 1 is a Belgian high-speed railway line which connects Brussels with the French border. 88 km long (71 km dedicated high-speed tracks, 17 km modernized lines).

The HSL 2 is a Belgian high-speed rail line between Brussels and Liège, 95 km long (61 km dedicated high-speed tracks between Leuven and Ans, 34 km modernised lines between Brussels and Leuven and between Ans and Liège).

The HSL 3 is a Belgian high-speed railway line which connects Liège to the German border, 56 km long (42 km dedicated high-speed tracks, 14 km modernised lines)

The HSL 4 is a Belgian high-speed railway line which connects Brussels to the Dutch border. 87 km long (40 km dedicated high speed tracks, 57 km modernised lines).

	**Sweden** Sweden today runs many trains at 200 km/h, including the X2 tilting trains, wide-body and double-decker regional trains, and the Arlanda Airport Express X3. Parts of the network can be relatively easily upgraded to 250 km/h. This requires new signalling system, catenary, removal of level crossings and new trains There are plans for a long completely new high-speed railway for 250–320 km/h, Stockholm-Linköping-Jönköping-Borås-Gothenburg, since the existing railways are relatively congested. An informal date suggestion by the Banverket is operation by year 2030
	**United States** Amtrak's Acela Express, currently the only line used for high-speed rail in the U.S. which runs the Northeast Corridor— from Boston via New York, Philadelphia, and Baltimore, to Washington, D.C.—at speeds averaging 68 mph (109 km/h) for the entire distance but intermittently reaching 150 mph (240 km/h) at times.

The High-Speed Rail current scenario over the world is depicted in Figure 1.8

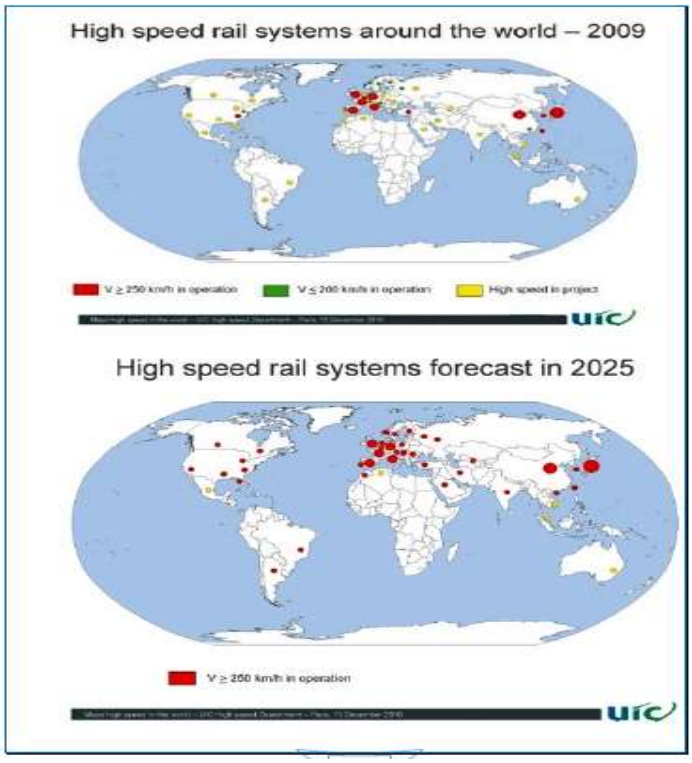


Figure 1-8: High Speed Rail scenario over the world

1.5.2 High Speed Rail Scenario in India:

In India, a thought for high speed operation was given in the first Governing Council Meeting (GCM) of RDSO in 1988 when it was decided to develop technology for operation of passenger services at 160 kmph on specified mixed routes and at 200 kmph on dedicated routes. A Task Force was set up in RDSO to study all the aspects of introduction of high-speed technology. In this connection, a feasibility study was conducted with the help of a Japanese Company (JICA) for Delhi-Kanpur section via Agra (448 kms) to run the trains at 250 kmph. Report was submitted in 1987. JICA recommended setting up a new corridor with terminal stations at Delhi, Agra and Kanpur with an anticipated cost of Rs.2200 crores at 1987 price indices. Two types of services as given under were suggested in the study report.

- ✓ Super express train at maximum speed to 250 kmph on new corridor of Delhi-Agra-Kanpur and
- ✓ Long distances express trains operating at 160 kmph to utilize dedicated track with facility of getting in and out of new corridor at Agra and Kanpur.

A traffic study was also conducted on following routes,

- Mumbai Vadodara-Ahmedabad (492 kms.)
- New Delhi – Kanpur – Lucknow (507 kms.)
- New Delhi – Agra (199 kms.)

Based on these detailed studies, Mumbai-Ahmedabad section was found having the best potential. However, cost being very high (Rs.4.9 crores per km. in 1987); if upgraded to the present day cost, It would come out to be about Rs.50 crores per km. Board closed the mission vide their letter no. 98/ER/3400/21/1 dated 28.03.01 addressed to RDSO.

Indian Railway is now again considering going for high speed. The Integrated Railway modernization plan Nov.2004 for the period 2005-2010 envisages high speed trains running at 250-330 kmph. Ahmedabad-Mumbai corridor was specifically identified for the feasibility study. In this regard, RITES Ltd., has carried out a feasibility study and financial appraisal for Mumbai-Ahmedabad corridor.

On December 18, 2009 Vision 2020 document was submitted in the parliament which envisaged the implementation of regional high-speed rail projects to provide services at 250-350 KMPH and planning for Dedicated Corridors resulting in superior technology and high speeds.

Some of the extracts of the Vision 2020 are indicated below:-

- "Vision 2020, **Page no.VI, High-Speed Rail Travel-** In the coming decade, Indian Railways must catch up with the developed railways of the world in the matter of speed of trains. The current effort to provide fast non-stop train services under the new brand of Duronto will continue. In addition, the Vision aims at raising the speed of regular passenger trains to 160-200 kmph on segregated routes, which will bring about a major transformation in train travel. For example, train journey between Delhi-Mumbai and Delhi-Kolkata will become an overnight service.

The Vision 2020 also envisages the implementation of at least 4 high-speed rail projects to provide bullet train services at 250-350 KMPH, one in each of the regions of the nation and planning for at least 8 more corridors connecting commercial, tourist and pilgrimage hubs.

Seven corridors have already been identified for technical studies on setting up of High-Speed Rail Corridors as mentioned in Table 1.13

Table 1-13: Proposed High Speed Rail Corridors

Sl. No.	Corridor	Total kms	Avg. Speed (Expected)
1	Pune-Mumbai-Ahmadabad	650	250 km/h
2	Delhi-Agra-Lucknow-Varanasi-Patna	991	300 km/h
3	Howrah-Haldia	135	300 km/h
4	Hyderabad-Dornakal-Vijayawada-Chennai	679	350 km/h
5	Chennai-Bangalore-Coimbatore-Kochi-Thiruvananthapuram	850	300 km/h

6	Delhi-Chandigarh-Amritsar	591	350 km/h
7	Delhi-Jaipur-Jodhpur	530	300 km/h

Source: Indian Railway Vision 2020

These could be built as elevated corridors in keeping with the pattern of habitation and the constraint of land. The Railways will use the PPP mode for investment and execution, and draw on frontier technologies incorporating the highest standards of safety and service quality"

- **"Vision 2020, Page-14, item no- 3.3 (f) High-speed trains-** Construction and operation of high speed lines is, however, very expensive and would require capital infusion and passenger patronage of a very high order. Massive capital investment would necessitate running of trains at frequent intervals of 5-10 minutes with sufficient load factors. Farebox revenues may not be sufficient to cover cost of infrastructure and operation for a long time. This would, therefore, call for innovative approaches; a mix of viability gap funding from government - both at central and State levels- and leveraging of real eState would be necessary to attract successful PPP interest in these projects."
- **"Vision 2020, Page-32, item no- 6.7 High Speed Corridors-**India is unique and alone among the major countries of the world in not having a single high-speed rail corridor capable of running trains at speeds of over 250 kmph. High speed corridors have played a major role in revitalization of Railways in Japan and Europe. Of late, high speed-rail networks are also getting built in China, Taiwan and USA. Indian Railways would follow a two-pronged approach in this respect. The first approach would be to raise the speed of segregated passenger corridors on trunk routes using conventional technology to 160 to 200 kmph. The second approach would be to identify a number of intercity routes, depending on viability, and build State-of-the-art high-speed corridors for speeds up to 350 kmph through on PPP mode in partnerships with the State Governments. Partnerships with the State Governments would be crucial as real-eState development would be a key element of viability of these high-cost projects. By 2020, at least four corridors of 2000 Kms would be developed and planning for 8 other corridors would be in different stages of progress."

1.5.2.1 Mumbai–Ahmedabad High Speed Rail Corridor

The first High Speed Rail corridor to be implemented in the Country, with technical and financial assistance of Government of Japan, has been identified from Mumbai to Ahmedabad. With total twelve stations in the States of Maharashtra, Gujarat and Union Territory of Dadra and Nagar Haveli, the corridor will have a length of 508.17 Km. Where high speed rail will cover 155.76 kms in the State of Maharashtra (7.04 Kms in Mumbai

sub-urban, 39.66 kms in Thane district & 109.06 kms in Palghar district), 4.3 kms in union territory of Dadra & Nagar Haveli and 348.04 kms in the State of Gujarat.

This High-Speed rail will provide total 12 stations namely Mumbai, Thane, Virar, Boisar, (in Maharashtra), Vapi, Bilimora, Surat, Bharuch, Vadodara, Anand, Ahmedabad and Sabarmati (in Gujarat). While a limited stop (in Surat & Vadodara only) service will cover this distance in 1 hr. and 58 mins, the all-stops service will take 2 hr. 57 min to cover this distance.

High speed rail will be operating at a speed of 320 Km/hr at an elevated (10 to 15 m) track above the ground on a viaduct all along except 26 kms in Mumbai, which will be underground. All stations will be elevated except Bandra Kurla Complex station (Mumbai), which will be underground.

Operational control centre for Mumbai -Ahmedabad High Speed Rail will be Sabarmati. Initially, trains will have total ten coaches with a seating capacity of 750 passengers, which will be further increased to sixteen coaches and seating capacity of 1250 passengers. There will be 35 trains per day/one direction, where there will be one train every 20 mins in peak hours and 1 train every 30 mins in non-peak hours. Train frequency will be further increased one train every 8 mins in future. Mumbai-Ahmedabad High Speed rail will be equipped to handle 17,900 passengers one way daily which will be increased up to 92,900 passengers in future.

The Key features of MAHSR is as below,

- ✓ Undersea Tunnel
- ✓ 92% elevated track
- ✓ Signaling system – DS-ATC Shinkansen technology
- ✓ Telecommunication system (Based on Shinkansen)
- ✓ Aerodynamic design- Reducing air drag

(Source: HSR Feasibility Study Report)

1.5.2.2 High Speed Rail project in Kerala

Historically, the Thiruvananthapuram–Mangalore high-speed rail corridor was mooted in the 2009-10 budget speech of the Government of Kerala. The project was cleared by the State Cabinet in February 2010. The Kerala State Industrial Development Corporation (KSIDC) was appointed as the nodal agency to develop the project. In September 2011, a special purpose vehicle, the Kerala High Speed Rail Corporation Ltd. (KHSRC) was formed to implement the project. The Delhi Metro Rail Corporation (DMRC) conducted the feasibility & detailed study and prepared Detailed Project Report (DPR) and submitted to the Government of Kerala in the year 2018. However, the proposal of HSR project has been dropped due to higher project cost. Estimated Cost of the HSR line is given in the Table 1.14.

Table 1-14: Cost details of Kerala High-speed Rail

Sl. No.	Name of Corridor	Distance (Km)	Estimated cost without taxes (Rs/Crore)	Estimated cost with central taxes and land cost (Rs/Crore)	Estimated cost with all taxes, octroi, & land cost (Rs/Crore)
1	Thiruvananthapuram to Kannur	430.00	77,361.00	86,735.00	90,663.00

Source: Executive summary of DMRC DPR for High speed rail, table 0.47 cost details

The high cost of High-speed rail is majorly attributed to higher track design parameters like flat curves, grades, long tunnels (longest tunnel is about 20 km) and high viaducts and cuttings. Given the high cost & higher ticket fare proposed, the State government decided to wind up the project and decided to consider the Semi High-Speed Rail option for Kerala.

1.5.2.3 Kerala's plan for introducing Semi High Speed Rail Project

The present rail transport system in the State is weak and has over-utilised its installed capacity. There is huge demand for travel resulting in long queues and associated discomfort in travel. The average speed of Express trains running in the State is about 50 kmph. There is demand that the Railway should device plans to introduce Mainline Electrical Multiple Units (MEMU), between major intercity routes with latest electronic passenger information system and engines on both sides to enable it to start like bus services to save time and increase efficiency.

Semi High-Speed North-South Rail Corridor:- Though Indian Railways are not planning to increase the speeds to the order of 200 kmph in section speed and 100-120 kmph in average speed, in view of the present limitations in track and coach technologies, there are proven technologies developed in the world already, whereby the trains can operate at speeds of 200-250 kmph with suitable tracks, coaches and signalling systems. If such semi high-speed technology and tracks are introduced in the State, the travel time can be brought down from the present 10-12 hours to 4 hours and the time-space divide existing in the north and south of the State can be reduced if not avoided. The State Government has assured to provide all necessary support for such a path-breaking new semi high-speed corridor including provision of required land and other resources.

The project of **Thiruvananthapuram-Kasaragod Semi High Speed Rail** is being proposed under the HSR policy of Govt of India where the route of Chennai-Bangalore - Coimbatore - Ernakulam- Thiruvananthapuram has already been identified. As the prevailing traffic in the Thiruvananthapuram-Kasaragod section of Southern Railway is

substantially high, and this being the main feeder route for the identified HSR route, this stretch has been selected for the project in first priority. As & when the need is felt, other sections forming part of the identified route in the GOI's policy will also be prioritized and proposed.

There is considerable commuter and daily or frequent travellers in all modes of traffic in the identified corridor in between the cities such as Thiruvananthapuram, Kochi, Kozhikode and Kannur in view of the fact that most of the commercial and administrative activities are located there and also that the population and developments in the State are evenly & linearly distributed. Hence, this project, which is expected to at-least partially take care of such traffic, also gets importance and priority for consideration under the GOI's latest policy for taking up New Suburban Rail System on Indian Railways, in MOR's letter No.2016/Proj/Policy Matter/4/2 dt.17-8-2018.

These policy issues are further discussed as relevant in Chapter 3- Review of Data.

Taking all the above into account, Govt of Kerala proposed the project to the Ministry of Railways (MoR). In turn, MoR supported the proposed project as a stand-alone elevated rail corridor of Govt of Kerala and offered to render any technical advice/support as and when required in the course of the execution of the project vide Railway Board's letter No. 2018/Infra/12/33 dated 16.10.18.

Under the policy guidelines discussed above, the Feasibility Study for the Semi High-Speed Rail Corridor Project was conducted from Thiruvananthapuram to Kasaragod by M/s SYSTRA and after getting nod from the Government of Kerala, the same was submitted to Railway Board for their approval. MoR has in turn accorded "In-Principle" approval and authorised K-Rail to prepare and submit the Detailed Project Report for the project for its sanction and to start pre-Investment exercises as required.

A detailed presentation on technical feasibility & financial viability of proposed SilverLine project was made before Railway Board on 10.12.2019 and Ministry of Railways accorded "in-principle" approval for taking up pre-investment activities of the project vide the Railway Board's letter no. 2019/JV Cell/KRDCL/SHRC dated 17th December 2019.

1.6 SELECTION OF POSSIBLE ROUTE

1.6.1 While on the selection of possible route for SilverLine, the existing rail alignment has been studied and found the technical difficulties in removing existing speed restrictions in existing IR lines in the route. These speed restrictions imposing section speeds of 80/90 KMPH and average speeds of 40-50 kmph cannot be physically removed due to huge developments around over the years and these restrictions will not allow higher speeds even on the 3rd and 4th lines if planned parallel.

1.6.2 Objective of SliverLine is for passengers to reach destinations (Thiruvananthapuram and Kasaragod from ends) in 4 hours comfortably (without getting tired) and commute to office, industry, etc. daily, before office hours. This requires an operational speed of 200 kmph throughout the entire stretch, maintaining an average speed of 130-140.

1.6.3 There are at present 431 curves in existing IR lines which are sharper than 1850m radius wherein speed of 200 KMPH cannot be reached safely. Additional running time of 4-5 hours will be required for negotiating through these sharp curves and hence total time of run will increase to 9-10 hours. This is not acceptable and will defeat the very purpose of high speed travel. If running time to reach destination is to be kept at 4 Hrs., then the alignment/route has to be mostly straight (or) with very flat curves of radius greater than 1850m. This is possible only if the alignment is taken away from existing IR's alignment for a length of about 203 Km out of total 529.45 km.

Drawings showing the proposed alignment are enclosed in "Drawing Annexure". As can be seen from there, the alignment between Thiruvananthapuram and Tirur (just after Thrissur) has several diversions away from existing railway lines and stations in order to;

- Avoid sharp curves (sharper than 1850m radius) and to have speed of 200 KMPH.
- Avoid built up areas, religious structures, etc.
- Have better road connectivity to the new stations.
- Locate stations proximate to industrues, IT centres, etc. and
- Reduce the cost of land and cost of construction.

1.7 SILVERLINE HELPS CITY MOBILITY IN KERALA

Kerala state being one of an extended city from end to end with its in-city and out-city movements of public one of the highest in the country, the SilverLine project tries to take care of the fundamental principles of City Mobility Planning by prioritising people over vehicles, planning cities and their mobility together, ensuring shared use of land and facilities, interaction with stake-holders, promoting equity, integration with other modes, sustainability by being eco-friendly, etc. Hence, all these aspects are given adequate importance in the studies carried out for the preparation of this Report.

1.8 ENVIRONMENT POLICY OF K-RAIL

1.8.1 Introduction- Sustainable Development

Sustainable development for inclusive growth as the key objective of the national economy in India would call for rapid growth of infrastructure. Rail transport is one of the major components of vehicle for growth of Indian economy. SilverLine is a major initiative in this direction to acquire the quantum jump in rail transport capacity in Kerala by providing high capacity, high efficiency backbone connecting the major economic hubs of the State.

It is natural K-Rail adopted a **Corporate Environment Policy** to go for not only an environment friendly mode of transport system but also taken initiative in each aspect of its working to foster growth and sustenance of healthy environment. K-Rail is thus committed towards compliance of all regulations and guidelines relating to environment. It is also an endeavour to adopt;

- Integrated environment management and practices.
- Efficient utilization of energy resources.
- Make efforts for preservation of ecological balance and heritage.
- Mitigation measure for noise, vibration and waste pollution.
- Sustain improvement of environmental performance of the organization.

1.8.2 Sustainable Development

Striving to be a responsible corporate entity, K-Rail tries to find a balance between the often-competing demands of the technical, economic and environmental commitments. K-Rail is committed for protecting and enhancing the natural environment in all its operations as far as possible and aim to go beyond compliance with environmental legislations. K-Rail endeavours to achieve sustainable development through integrating sustainable development construction methodologies and approaches in its all construction bid documents and implementing framework at the onset of construction chain phases.

1.8.2.1 Avoiding Ecologically Sensitive Areas While Routing Lines

Development of Semi High Speed Rail (SilverLine) line, now popularly known as SilverLine, has avoided any forest involvement. K-Rail's proactive approach towards environment is reflected from the initiatives taken that SilverLine alignment have been selected to avoid or minimize damage to the environment by avoiding sensitive forest land.

1.8.2.2 Installing Noise Barrier near Sensitive Receptor

Educational institutions, medical centres, religious places close to the SilverLine line are the primarily susceptible site for high noise level. K-Rail has taken initiative to safeguard sensitive receptor from high noise. Noise mitigation measure in the form of noise barrier at sensitive receptors have been planned during operation phase. A thick canopy of green belt along the corridor has also been proposed to mitigate balance impact of high noise. For reducing the impact of noise on sensitive location while operation of rails, noise barrier has been provided to attenuate the impact of crossing train noise and vibration on the sensitive receptors.

1.8.3 Green Initiatives of SilverLine

1.8.3.1 Green Initiatives

The following ideas of green initiatives in the project design and implementation have been planned.

- Use of 100% renewable energy including for traction and avoid use of fossil fuels.
- Reduction in carbon emission.
- Adoption of water conservation procedures in staff quarters & stations.
- Rain water harvesting in staff quarter complexes and stations.
- Harnessing of solar energy in staff quarters, stations & substations and other buildings for street and site security lightening.
- Use of only LED lights to reduce the consumption load.

1.8.3.2 Green Energy

100% green energy from renewable energy sources will be used during operation phase including for traction purpose. Innovation in solar generation across corridor in trains, via-ducts, walls & energy efficient stations & depots has been opted.

1.8.3.3 Green Project

Strategies proposed to be adopted during construction includes recycling steel and concrete; diversion of construction waste from landfills through reuse and recycling; use of new, low emission construction equipment, replacement of inefficient truck engines and irrigation pumps, urban forestry program etc. The Station buildings, depot, administrative building and other service buildings will be designed based on the platinum rating standard of Indian Green Building Council.

1.8.3.4 Station Development As Green Building

Buildings are a major energy consuming sector in the economy. About 35 to 40% of total energy is used by buildings during construction. The major consumption of Energy in buildings is during construction and later in lighting or air-conditioning systems. This consumption must be minimized.

A green building uses less energy, water and other natural resources creates less waste & Green House Gases and is healthy for people during living or working inside as compared to a standard Building. Another meaning of Green Structure is clean environment, water and healthy living. Building Green is not about a little more efficiency. It is about creating buildings that optimize on the local ecology, use of local materials and most importantly they are built to cut power, water and material requirements.

Green building offers some or all of the following benefits to the building owner and building occupants:

- Reduced maintenance/ replacement costs over the life of the building
- Energy conservation
- Improved occupant health and productivity
- Life cycle cost savings
- Lower costs associated with changing space configurations.
- Greater design flexibility

1.9 ADVANTAGES OF SEMI HIGH SPEED RAIL SYSTEM FOR PASSENGERS

The key advantages of Semi High Speed Rail systems over the conventional rail based systems or road systems are:-

- Travel speed- Travel with a high level of speeds in all needs of people.
- Travel time - A short travel time from door to door.
- Frequency- A high level of availability of services.
- Reliability- A reliable system of transport, which works efficiently under all conditions of weather.
- Accessibility- Entry to train services without long check in times, waiting queues.
- Price- Not to cost more than, any comparable means of travel.
- Comfort- There is a higher level of comfort (in terms of space, acceleration, noise, light, etc.) than all other modes of journey except of course by air.
- Safety- Semi High Speed trains are the safest of all transport media internationally.
- Freedom to relax - During the travel, passengers are not tied to their seats as in most other modes in that one gets liberty to go everywhere and every time one wants, say to the restaurant, or to similar facilities available in the train. Neither seatbelts are necessary nor use of electronic devices are limited.

These are apart from a host of other major project benefits including its eco-friendly nature which are discussed in subsequent chapters.

1.10 IN-PRINCIPLE APPROVAL FROM MOR (Railway Board)

1.10.1 A detailed presentation on technical feasibility & financial viability of proposed SilverLine project was made before Railway Board on 10.12.2019 and Ministry of Railways accorded “in-principle” approval for taking up pre-investment activities of the project vide Rly Bd’s letter no. 2019/JV Cell/KRDCL/SHRC dated 17th December 2019. The salient points of Minutes of Meeting, Railway Board, as communicated vide letter no. 2018/JV Cell/KRDCL/BD Meeting dated 18th December 2019, are given hereunder;

- *"The proposal is for standard gauge. In view of various advantages of Standard Gauge on higher speeds and proven technology available world over, it was agreed in principle to proceed with Standard Gauge for this stand-alone system.*

- K-Rail *has proposed 200 KMPH speed for the proposed project. High Speed was not considered due to higher project cost. In view of the inter station distance of 50 Km, the proposed speed of 200 KMPH was reasonable and acceptable compared with 160 KMPH for which technology is available in India.*

- *The alignment in Tirur-Kasaragod section is proposed parallel to the existing railway alignment. A portion of railway land will be used by the proposed alignment with a track center of 7.8m. It was confirmed by the MD,* K-Rail *that the cost of railway land used for the proposed project can be adjusted towards the Railway's share of equity in the SPV.*

- *It was Stated by ME that all LC gates in the Tirur-Kasaragod Section has to be replaced with ROB/RUB and MD,* K-Rail *has clarified that the estimates caters for the elimination of remaining LCs which are not sanctioned in this section.*

- *Board has directed* K-Rail *to explore the feasibility of PPP model for execution of the project.* K-Rail *has agreed to explore the feasibility of PPP model.*

- *Board has also directed* K-Rail *to dilute the shareholding of Railways in the project SPV. MD,* K-Rail *has Stated that as per the State JV agreement, the SPV shareholding by* K-Rail *can be reduced up to 26% of the total shareholding of the SPV. Hence during DPR preparation, efforts will be made to dilute the shareholding in SPV by* K-Rail*, thereby the Railways and GOK contribution to SPV will be reduced. Alternatively private equity from NRIs and other entities will be proposed.*

- *FC has expressed concern about the land acquisition issues in Kerala. Principal Secretary (Transport), GOK has assured that all efforts will be made to acquire the land and proper compensation will be given to the affected parties.*

- *FC has mentioned the need for additional stops in Kerala. MD,* K-Rail *clarified that additional feeder/aggregator stations limited to three are proposed between two main stations. Accordingly 27 feeder stations in the entire corridor are being studied".*

1.10.2 With the in-principle approval for taking up pre-investment activities having been accorded by Ministry of Railways, K-Rail has planned to work for the following;

- Initiation of land acquisition process.
- Preparation of detailed drawings for bridges & structures proposed in the project.
- Preparation of design & drawings for station layout and entry & exit arrangements.
- Initiation of field survey & investigation such as LiDAR, Geotechnical, Traffic, Environment & Social, etc.

1.10.3 In order to expedite the project and to get the suggestions to make the project more fruitful, a series of meetings/discussions/presentations have taken place with concerned Railways & Govt of Kerala authorities. In this regard, meetings were held with Southern Railway, High Powered Committee of Government of Kerala, chaired by the Honl CM, Chamber of Commerce, etc. A presentation of the project was given to all the MLAs of the constituencies through which the alignment passes through and their feedback was obtained. Detailed deliberations to make the project more feasible & viable, took place during these meetings and all the relevant suggestions have been incorporated in this Detailed Project Report.

1.11 REFERENCES

India do not have any railways that can be classified as New high-speed rail (more than 200 Kmph) or semi high-speed rail (up to 200 Kmph). The current fastest train in India is the Gatiman Express between H. Nizamuddin and Agra with a top speed of 160 km/h. So, this project is in a new territory as far as Indian Rail scenario is concerned. Hence references for the semi high speed rail in Indian context is not readily available as a result of which the following references have been used for the preparation of this report. More references shall be added during the further study if required.

- Feasibility Report of Construction of 3RD & 4TH Line Between Thiruvananthapuram and Kasaragod for Running of Semi High Speed Trains– Prepared by Kerala Rail Development Corporation Ltd., Thiruvananthapuram.
- Kerala High Speed Rail Corridor between Thiruvananthapuram and Kannur Detailed Project Report – June 2016, Prepared by DMRC.
- Technical Assistance Consultant’s Report of People’s Republic of China: Lanzhou-Chongqing Railway Project Financed by the Asian Development Bank.
- EUROPEAN STANDARD (UIC) Railway applications – Track - Track alignment design parameters - Track gauges 1435 mm and wider - Part 1: Plain line.
- Geo technical aspects for the construction of Shinkansen by Dr. M FUJII.
- Delhi-Chandigarh Semi High-Speed Project SEMI HIGH SPEED TECHNICAL FEATURES REPORT.

- Joint Feasibility Study for Mumbai-Ahmedabad High Speed Railway Corridor by Japan International Cooperation Agency (JICA) and Ministry of Railways, Republic of India (MOR).
- California High Speed Rail project: Typical cross sections.
- Site visits.
- Various presentation and discussions with Client K-Rail and the other stakeholders.

DETAILED PROJECT REPORT

SEMI HIGH SPEED RAIL CORRIDOR
THIRUVANANTHAPURAM TO KASARAGOD

VOLUME II - MAIN REPORT
(PART A)

CHAPTER 2
OBJECTIVES OF THE REPORT

2 OBJECTIVES OF THE STUDY AND THE REPORT

2.1 OVERALL OBJECTIVE OF THE REPORT:

The primary objective of study & report is to provide innovative & feasible solutions for the efficient transport of people and goods within the State and outside for the planned development of the State . The draft transport policy of the Government of Kerala States that *"The quality of transport system in Kerala requires much improvement. Although road transport dominates the transportation scenario in the State, people depend on railways for long haul transport needs. The service levels in train journeys are far from satisfactory. Reservation of seats and berths in general are not available on demand and one has to book tickets more than one month in advance. The public transport system is unreliable, costly and remains very rudimentary".*

Government of India has formulated various plans for improving the mobility of people and goods across the country and has identified the transport system as the 'engine of growth' for the country. The existing transport system consisting of various modes like public and private road transport, highway and railway systems, air and waterways are inadequate for the growth requirements of the State with 21st Century and there is an urgent need to improve the regional transport system across the State to facilitate speedier, comfortable and economical transport available for the public, industry and commercial wings of the economy.

2.2 SCOPE OF WORK FOR THE STUDY

2.2.1 The scope of work for preparation of DPR is outlined below:-

(i) Review of all data, reports and statistics on the need for a new rail-based system.
(ii) Collection and study of traffic data to see the potential of Ridership for the new system including possible passenger and goods (RORO type) traffic.
(iii) Study of ground and natural characteristics of the region and identify a possible alignment for the Semi High Speed Rail system.
(iv) Selection of a structural system for supporting such a Semi High Speed Rail corridor.
(v) Selection of suitable sub-systems for Rolling Stock, Power Supply and distribution, Signaling and Control, Operating and Safety, Train Operation planning, Fare Collection and Ticketing, etc including their maintenance.
(vi) Study the impact of running of such a transport system on the Social and Environmental conditions of the State including identifying their rehabilitation requirements.
(vii) Estimate the Cost of Provision and Operation of such a system and identify sources of funding.
(viii) Study the viability of Providing and Operation of such a system Financially and Economically.

(ix) Prescribing a Project Implementation Mechanism including discussions with stake holders.

2.2.2 Scope of work of DPR includes-

(i) Review of data and existing conditions analysis & fixing planning parameters.
(ii) Travel Demand Forecast.
(iii) Study of alignment options and fixing final alignment including topography, geology, geotechnical, hydrological surveys as required.
(iv) Preparing Engineering Structural report and Land acquisition report.
(v) Station identification and Planning report including Architectural, Urban planning, Transit oriented development, etc.
(vi) Identifying and preparation of Rolling Stock and Other Systems reports.
(vii) Preparing a Traffic Management plan and Safety plan.
(viii) Assessing and preparing Environmental Impact Assessment report.
(ix) Preparation of land acquisition details.
(x) Preparing Social Impact Assessment and Resettlement and Rehabilitation plan.
(xi) Utilities Identification and Shifting plans.
(xii) Draft Detailed Project Report including Detailed Cost Estimate.
(xiii) Stake Holder Meeting Report on land, industries, commerce, funding agencies.
(xiv) Submission of Detailed Project Report with all accessories.

2.2.3 Detailed Project Report

The Detailed Project Report shall integrate all the previous reports, studies conducted, assessments made along with recommendations providing relevant summaries and incorporating detailed data and comments specific to the DPR for facilitating obtaining necessary approvals and sanction and identification of sources of funds and agencies for implementation of the project.

2.3 GENERAL PLANNING PARAMETERS

For planning the project's technical requirements to achieve its main objectives, following General System parameters are laid down. These are fundamental in nature and are based on similar systems working in other countries and also based on earlier studies carried out. DPR should take these into account while formulating its Basic and Detailed Planning & Design Parameters for various sub-systems proposed.

(i) The Semi-High Speed Rail System (SilverLine) shall be a fast rail system between Thiruvananthapuram and Kasaragod with about 11 stations located suitably at populated activity centres giving connectivity to city centres, industries, airport, etc, on a well-planned and least intrusive alignment.
(ii) It should have a pattern of train series including non-stop trains and trains stopping at all stations to provide connectivity to all major cities reaching in 1 to 1 and ½ hour and end-to-end in approximate 4 hours.

(iii) The SilverLine trains should have an appropriate numbers of passenger seating, sleeping and standing accommodation to the passengers expected to migrate to the new system from existing modes of transport and prospective passengers developing along with the growth of the State.

(iv) The system shall be of Standard Gauge 1435mm, with suitable Engineering structures, Rolling Stock, Control and Operating sub-systems to run trains at a maximum design speed of 220 kmph presently with potential to go up to 250 kmph in future.

(v) The Sub-Systems should be on the lines of internationally adopted similar systems and should be acceptable to the Indian requirements and shall be of appropriate standards providing reliability, safety and comfort for the passengers and other users at optimal cost of provisioning, operating and maintaining such systems.

(vi) Stations should be designed to accommodate 15 coach passenger trains and also other type of trains identified to carry various traffic as planned.

(vii) The SilverLine should be planned for starting execution of works and procurement from 2020 for commissioning by 2025. All assessments and time-planning should be for horizon years 2025-26, 2029-30, 2041-42 and 2052-53.

These parameters have been decided based on preliminary studies conducted for the project and based on experience of different projects by different agencies reported so far. However justification for adopting some of these major parameters is given in the following paras.

2.3.1 Need for SilverLine in Kerala State

The ground conditions in Kerala necessitating provision of such a transport system across the length of the State has been brought out in detail in Chapter 1. Briefly the points are:

a) The prime objectives of Semi High Speed Rail Corridor are:
   - Provide Reliable, Comfortable, Affordable, Safe & Sustainable transportation within Kerala.
   - Reduce transportation time to boost economic growth of State.
   - Provide Green Corridor by reduction in pollution.

b) On the road front, traffic has been growing at a rate of 10 to 11 percent every year, resulting in excessive pressure on the roads of the State. The major road network of Kerala, though well connected, faces severe constraints due to the urban sprawl and the haphazard ribbon development all along the routes. The existing traffic levels at most stretches are excessive and beyond the road capacity. Capacity augmentation of existing roads is beset with problems relating to limited right of way and land acquisition.

c) The existing railway network and the highways in Kerala are not amenable for faster travel due to heavy traffic density and existence of sharp curves & steep gradients highly undulating terrain structure in this part of the country. Average speed on road and by trains is among the lowest of all regions of our country. The average speed of journey by rail and road in the State is about 30% to 40% lower than in the neighbouring States. The journey becomes even slower in the rainy seasons with high intensity of rainfall in the months of June to August because of deterioration in the condition of the roads. Because of the adverse terrain, there is little scope of physically raising the speed of trains and road vehicles on the existing systems apart from its enormous cost. Speed of travel on the railway tracks has stagnated for the past many years because of massive requirement of land acquisition for improving the same. Difficulties in land acquisition of the already developed lands by the side of existing roads and rail lines is another major reason for not undertaking such improvements over a period of time. There is a widespread realization that the economic and social life in the State of Kerala suffers heavily from the slow speeds of travel on its existing highways and railways.

d) Vehicular emission and noise from these vehicles are severe in the three major cities of Kerala namely, Thiruvananthapuram, Kochi and Kozhikode. Development of road infrastructure has not kept pace with exponential increase in number of vehicles. This has resulted in traffic congestion and the resultant in air quality deterioration.

e) Railways are essentially the cause for Industrial growth in the nation and it remains the largest employment provider for the huge population of the country. The total length of tracks used by Indian Railways is about 111600 Km and the total route length is about 67368 kms. As per system map of southern railway of 2018, total route length of railways in Kerala is 1045 route kms, which has been found to be inadequate to meet the growing needs of the state.

f) The increasing need for movement of people and products at the local, regional, national, and international levels has placed extreme demands on transportation systems, especially in the developing world. Highway and air transportation system congestion are growing fast, and a transportation network developed to meet the needs of an age in which there was less travel and movement of materials, is ill-suited to today's needs. In most of the major cities in Kerala, there is no space available to expand the existing highway and rail infrastructure, and there is strong environmental opposition when such expansion is proposed.

g) There is a high demand for faster and smoother transport facilities in the north-south corridor of Kerala which is not being well served by the existing systems. Narrow roads on uneven terrains and slow speeds on road/rail results in almost 10 to 12 hours of running time for a short distance of 560 km between

Thiruvananthapuram and Kasaragod causing huge wastage of productive man hours, efforts and resources of the population.

h) One key to solve today's transportation problems is to develop systems that meet markets served poorly by the existing transportation infrastructure. **Semi-High-Speed Rail system fits snugly in just such a niche: the medium-distance travel market—too far to drive and too short to fly.**

i) With the above in mind, the Government of Kerala has decided to build the Thiruvananthapuram - Kasaragod corridor as a Semi high Speed Rail line (SilverLine), covering the developed regions which are the most densely populated regions and growth centres of the State.

2.3.2 Selection of Possible Route

Selection of the possible route for providing such a rail system is critical. It depends on the present and future nature, type and systems of overall traffic and how the State plans to develop various economic regions for obtaining best possible growth in the 21st century. Based on various traffic studies conducted by the Govt for various purposes and at different points of time, it has emerged that the Thiruvananthapuram city, capital of the State located at the southern end of the State and Kannur or Kasaragod city located at the northern end, which carries the highest traffic all the time in the State, is the corridor for development in the visioned future. This corridor is visualised as the nerve system of transport in Kerala, which will attract considerable traffic in the Trip Attracting and Generating Zones in the State. Existing transport facilities in this corridor are not able to meet the requirements anticipated in the visioned time frame. This shall pass through the district headquarters and city centres of the 11 districts lying in the alignment. While selecting this proposed route, the existing rail and road corridors have been studied and it is found that the structural and technical difficulties in improving the rail/road sharply curved and steeply graded/sloped alignment for removing existing speed restrictions and unsafe conditions is almost impossible. These speed restrictions imposing section speeds of 80/90 kmph with serious additional local restrictions with actual average speeds of 35-45 kmph, cannot be physically removed due to huge developments all around over the years and if tried will involve huge land and property acquisitions in developed and populated activity centres of the State. This is the reason why the initially planned parallel 3rd and 4th rail lines could not be pursued.

While providing an additional transport system across the State, the main objective of the SilverLine is for passengers to reach the destinations (Thiruvananthapuram and Kasaragod from ends) in less than 4hrs comfortably (without getting tired) and to commute to both office, industry etc. daily, before office hours. This requires a sectioned speed of 200 kmph throughout the entire stretch, maintaining an average speed of 130-140 kmph for the trains. There are at present 431 curves in existing IR lines which are sharper than 1850m radius where the running speed of 200 kmph will not be possible. Additional running time of 3 and ½ hours due to speed restrictions will be required for

negotiating these sharp curves. With necessary stoppings and timings required for maintenance, etc., the total time, even if other stretches could be improved, will come to about 9 hrs, which is not acceptable and will defeat the very purpose of having an additional transport system to be planned in 21st century for the needs of a generation for whom time is the most valuable asset. If running time to reach destination is to be kept at 4 hrs, then the alignment/route has to be mostly straight and if that is not possible, with very few and flat curves of radius greater than 1850m. This is possible only if the alignment is taken away from the existing IR's alignment for a length of minimum 203 km out of total 529 kms as per the initial studies conducted including that of the Feasibility Report for this project and the High Speed Rail project studied by DMRC earlier.

Based on the above, this possible route between Thiruvananthapuram and Kasaragod will consist of an alignment parallel to existing rail lines between Tirur (next station after Thrissur in SilverLine corridor) and Kasaragod but will have several diversions away from existing railway lines and stations in between Thiruvananthapuram and Tirur in order to:

a) avoid sharp curves (sharper than 1850m radius) to have maximum speed of 200kmph.
b) avoid built up areas, religious structures, etc., and reduce acquisition of houses and properties,
c) have better road connectivity to the new stations.
d) locate stations proximate to populous places, industries, IT centers, etc, and
e) reduce the cost of land and cost of construction.

2.3.3 Selection of Semi High Speed over High Speed Rail

As seen from existing HSR projects in other countries and that under construction/consideration in India, the high cost of high speed rail is majorly attributed to: higher track design parameters like flat curves, grades, long tunnels (longest tunnel is about 20 km) and high viaducts and cuttings. Given the high cost, Govt of Kerala decided to drop the Kerala High Speed Rail project which was studied by DMRC.

Semi High Speed Rail (SilverLine) with 200kmph potential has been preferred for the selected route in Kerala State in place of High-Speed Rail (300-350 kmph) due to specific reasons listed as under;

a) Heavy cost of the High Speed Rail which is almost double of SilverLine cost. HSR costs about Rs 200 crore per km against the likely cost of about Rs 100-110 crore for SilverLine.

b) Heavy passenger fares will be required to justify the cost of construction of High Speed Rail to make it viable. The Railway will have negative effect on the ridership.

c) A running time of about 4 hrs between Thiruvananthapuram and Kasaragod, duly reaching in between cities in 1 ½ to 2 hrs is considered adequate for the level and type of traffic anticipated in Kerala. This will provide effective working day at both ends for

business and office going passengers. For achieving this, 200kmph is considered to be adequate.

2.3.4 Selection of Operating speed 200 kmph instead of 350 kmph

Following reasons are attributed for selection of operating speed 200 kmph over 350 kmph,

a) The cities and activity centres in Kerala are so closely located that such high speeds of 350 kmph cannot be realized effectively in running trains. The frequent stopping required to cater to these specific requirements of the State does not permit such high speeds.
b) The cost of providing HSR at 300 kmph will be very high as it will require long lengths of tunnels and viaducts to negotiate the highly uneven terrains [as proved in DMRC's report on HSR.
c) Rolling stock for 250 kmph are expected to be less design intensive as aero-dynamic designs may not be required and hence expected to be cheaper. HSR systems are very high in technology and cost.
d) There is a possible requirement of development of technologies for the medium speed of 200 kmph. It is also felt that this project will help in standardizing technology and policies on SilverLine which could be used in marginally less intensive traffic routes in other parts of the country, as being done by the Chinese Railways presently.

2.3.5 Standard Gauge (SG) over Broad Gauge (BG) or Other Gauge

Standard Gauge has been selected for the Semi High Speed Rail project over the Broad gauge as the project contemplates 200 kmph speed initially with a plan to raise it to 250 kmph later. This is not possible with Broad Gauge. Kerala's present rail network on BG is very slow with an average speed less than 50 kmph, taking 10-12 hrs for the 560 km distance between Thiruvananthapuram and Kasaragod. Kerala needs a faster system to cover this distance in 3 and ½ hour to 4 hours as the mobility of travellers has been hampered by the present speed and growth of the State in various industries including tourism and IT are badly affected.

SG is a proven technology all over the world for higher speed operations and speeds on SG systems have gone beyond 350 kmph in several countries. India is also aspiring to raise train speeds and for this purpose a High Speed Railway policy has been issued by the Govt of India. Govt is planning to develop high speed rail systems in different areas including Kerala as per the above policy knowing the railways will be the future growth engine for the country.

Standard Gauge (SG) trains can obtain higher speeds compared to Broad Gauge (BG) trains in sharp curved and steep graded lines due to reasons like their Inherent better

stability, lighter coaches, simpler structural systems, etc. That is the reason why world over all railways have gone for SG.

BG is available only in India (and also Pakistan) where speeds are historically low. In BG in IR, high speed operations have not been found feasible as existing technologies are not adequate for such speeds and available track and coach designs are not supporting such speeds. IR have been attempting to raise speeds on BG rails for several years. Maximum speed achieved so far is 160 kmph. If we adopt BG for the Semi High Speed rail, maximum speed will get limited to 160 kmph only for the years to come. That is the reason why projects like Mumbai – Ahmedabad HSR , Delhi-Meerut RRTS and others have adopted SG.

SG systems internationally are generally safer. SG coaches available internationally are very good, comfortable and safe for such operations. Well proved technologies are available for all systems in SG whereas developing the same in BG and updating it over the years would be a herculean task. Opting for 3.2m or 3.4m wide bodies coaches in SG which are also available presently will make passenger capacities as equal to that of BG coaches. International funding agencies require proven technologies in systems.

Land requirement for SG is comparatively less and it is a major issue in Kerala where land availability is very poor and cost of land is high.

Integration of Semi High Speed Railway with existing railway is not a major issue and will be met to a large extent by connecting the SilverLine alignment with existing IR system at major stations like Thiruvananthapuram (Kochuveli), Thrissur, Kozhikode and Kasaragod.

Govt of India is planning to develop High Speed technology in Standard Gauge keeping the future of rail development in India and the scope for exports in view.

2.4 NEED FOR PARADIGM SHIFT

The present State of the Kerala State's development scenario and traffic conditions need a paradigm shift in thinking involving out-of-the-box solutions to the type of issues and problems faced by the transport sector in the State. It calls for innovative solutions away from the conventional thinking involving low cost solutions and limited upgradations which will not pull out the State from its deep-rooted problems. This proposal is to provide a SilverLine Railway with two more additional railway lines in the State of Kerala for a 529.45 kms long dedicated green corridor with 200 kmph speed potential connecting the South & North corners of the State. This will mostly be a green field corridor even where it is parallel to the existing railway alignment for about 200kms from Tirur to Kasaragod by way of innovation in facilities and methods of construction. This SilverLine corridor will have passenger capacity equivalent to 6 lane road highway and will have substantial reduction in fuel consumption, accidents and pollution as secondary benefits.

DETAILED PROJECT REPORT

SEMI HIGH SPEED RAIL CORRIDOR
THIRUVANANTHAPURAM TO KASARAGOD

VOLUME II - MAIN REPORT
(PART A)

CHAPTER 3
REVIEW OF EXISTING DATA & REPORTS

3 REVIEW OF EXISTING DATA AND REPORTS

3.1 INTRODUCTION

Globally, there are about fifty high speed rail lines which are purpose-built and trains run at speeds over 250 kmph on a regular basis. In most cases, they are dedicated high speed passenger lines and in a few cases cater to both passenger and goods movement. Several new lines are also under construction or planning with speeds above 300 kmph and into 350 kmph. Japanese, Chinese, French and some other lines are built for speed of 350 kmph presently. High Speed Rail is the new era of railway industry. With the growing economy and population, time is the major factor affecting day to day life as well business all over the world. Therefore, around the world, proposals for new high-speed lines are booming. Many existing railway systems are experiencing ever increasing passenger and freight traffic and some routes are even showing signs of stress, such as poor punctuality and overcrowding, often due to the capacity constraints of their systems. This is leading to calls in various countries for deciding standards for new high-speed lines to be built in future. UIC, Japanese and European standards provide basic standards for various assessments and designs. In this connection, available data and reports are reviewed in this chapter. Norms followed in various systems are brought out with a view to decide on the system parameters to be adopted for Kerala's Semi high Speed Rail corridor (SilverLine).

This chapter also shows a methodology for preparation of DPR.

3.2 REVIEW OF HIGH SPEED RAIL AROUND THE WORLD

In the following paras, evolution of high speed rail is described with allusions to the current scenario of high speed rail developments in India. A few foreign systems are more closely studied for their overall performance and observations included. This chapter also enlightens on the key features, standards and design parameters of various studies made for High-Speed or Semi High-Speed or similar rail based systems in India and abroad.

The Italian ETR 200 (Figure 3.1) in 1939 was the first high speed service train. It achieved the world mean speed record in 1939, reaching 203 km/h near Milan.

Figure 3-1: The Italian ETR 200

Concept of High-Speed train has started developing throughout the world after the world war-II. Japan has taken a lead in this field followed by several European Countries viz France, Germany, Sweden etc.

During last 50 years enormous advancement has taken place in this field. Several historical milestones have been achieved by various countries. It will be interesting to see the evolution of speed record in Railways since its inception in table 3.1.

Table 3-1: Speed Record in Railways since Incpetion

YEAR	SPEED (km/h)	TRACTION	LOCOMOTIVE / TRAIN
1804	8	Steam	Trevithick's Locomotive
1825	24	Steam	Stephenson's Locomotive no. 1
1830	48	Steam	Stephenson's Rocket
1848	96.5	Steam	Boston & Maine "Antelope"
1901	162	Electric	Seimens & Halske Railcar
1903	206.7	Electric	Seimens & Halske Railcar
1903	210.2	Electric	AEG Railcar
1938	202.8	Steam	A4#4468 "Mallard"
1955	326	Electric	Alstom Electric Loco CC7107
1955	331	Electric	Alstom Electric Loco BB9004
1981	371	Electric	TGV-PSE 16
1981	380.4	Electric	TGV-PSE 16
1988	387	Electric	ICE-V BR-410-001
1988	406.9	Electric	ICE-V BR-410-001
1988	408.4	Electric	TGV-PSE 88
1990	515.3	Electric	TGV-A (Atlantique) 325
2007	574.8	Electric	TGV V150 (LGV Est) 4402

3.2.1 Chronological Development of High-Speed Rail in Various Countries

The first HSR line was Japan's Shinkansen service between Tokyo and Osaka, which opened in 1964 with a maximum speed of 130 mph (210 km/h). It is a dedicated HSR system, meaning that it was built especially for high-speed trains and only high-speed trains operate on it.

France took the next big step for shared-use HSR with the introduction of the Train à Grande Vitesse (TGV) program in 1981. The first TGV line, running between Paris and Lyon, was a dedicated line with shared-use segments in urban areas. It proved that high-speed rail could attract a large share of airline passengers in medium-distance markets.

Germany's high-speed train system, the InterCity Express (ICE), began operation in 1992. Germany used a coordinated program of improvements in infrastructure, rolling stock, and service, upgrading much of the mainline track network for speeds of 125 mph (200 km/h). This allowed ICE trains to efficiently share tracks with other trains and enabled Germany to expand its HSR network quickly and cost effectively.

The only HSR system operating in the **United States** today is on Amtrak's Northeast Corridor. In 1968, the corridor's private sector owner introduced the Metroliner service,

consisting of track improvements and new higher-speed rolling stock. The Metroliner's initial top speed was approximately 110 mph and operating speeds eventually reached approximately 125 mph (200 km/h).

The speed of construction of High-Speed lines is increasing day by day and several new countries are joining the high-speed club. Length of high-speed rail routes and their speeds in various countries is given in the table 3.2.

Table 3-2: HSR Routes and their Speed in various countries

(as on Dec 2014)

Country	Total Network Length In kms	Test run speed record in kmph	Average Speed Of Fastest Scheduled Train in kmph
Belgium	214	347	237
China	19369	394	313
France	2036	574	272
Germany	1334	406	226
Italy	923	368	178
Japan	2664	443	256
Netherlands	1200	336	140
South Korea	819	355	200
Spain	3100	404	236
Switzerland	79	280	140
Taiwan	336	315	245
Turkey	1420	303	140
United Kingdom	1377	335	219
Total	**34871**		

Source: A resource book on High Speed Rail Technology compiled by Mr Gaurav Agarwal, Director (Efficiency & Research)/Mech Engg. Ministry of Railway, Govt of India.

Majority of High-Speed Railway lines under construction are in China, France, Germany and Japan. In recent past USA, UK and India have taken definitive steps to create high speed rail corridors. Thus, in future more corridors of high-speed rail are expected from these countries apart from China and Japan. Table 3.3 gives the length of different high-speed lines under construction in various countries.

Table 3-3: Length of HSR lines under construction

Country	Length under Operation (km)	Length under construction (km)
Austria	292	210
Belgium	209	0
China	19369.8	16280
Denmark	5	60
France	2036	757
Germany	1334	428
Italy	923	125
Japan	2664	782
Netherlands	120	0
Poland	85	322
Russia	1496	0
South Korea	819	585
Spain	3100	1800
Switzerland	80	57
Taiwan	339	9
Turkey	1420	1506
UK	1377	0
USA	362	483

Source: A resource book on High Speed Rail Technology compiled by Mr Gaurav Agarwal, Director (Efficiency & Research)/Mech Engg. Ministry of Railway, Govt of India.

Thus, a total of 23,404 km of high speed rail length is under construction out of which 2/3rd is in China.

3.2.2 Latest HSR Projects

Although as mentioned above, HSR has been developed in 1964, but for the study & its impact on industry purpose, we are mentioning latest HSR projects developed in any country for updating our data**.**

3.2.2.1 The Netherlands – Amsterdam to the Belgian Border High Speed Rail Link

3.2.2.1.1 **Project background*:*** The High-Speed Line South (HSL or HSL-Zuid in Dutch) is a 125-kilometer HSR line in the Netherlands, which links Amsterdam to the Belgian border. The HSR line became operational in 2009.

HSL is part of the Trans-European Transport Network (TEN-T) of high-speed train lines although, because of the financing structure, the influence of TEN-T was very limited.

Connecting the Netherlands with the rest of the European high-speed passenger network was an important motive behind the project.

The Netherlands HSR project was developed by a special project organization, HSL-South.

The construction of HSL was completed in 2007; however, operations only started in 2009 after a 4-year delay because of problems with the rolling stock order and the security system. It is estimated that the construction costs amounted to approximately €7.2 billion. The HSL privately financed infrastructure contract with a value of €1.2bn reached financial close in December 2001.

3.2.2.1.2 Objectives and intermodal competition: The primary objectives for the development of the network are:

- Linking the main ports of Rotterdam, Schiphol and Amsterdam to the TEN-T network of HSR.
- Providing impetus to economic development.
- Reducing air traffic for medium distances within Europe.

One aspect of the extension of HSR to the Netherlands and competition with air was the inclusion of KLM Royal Dutch Airlines in a two-part consortium which has a 15 year franchise to operate HSR. High Speed Alliance (HSA), the operator of the HSL-Zuid network, is in fact a Joint Venture between KLM Royal Dutch Airlines which owns 10 per cent and Dutch Railways (NS) which owns 90 per cent. The franchised HSR line runs from Amsterdam to Rotterdam and the Belgian border. The Dutch view to this was that the HSR station at Amsterdam Airport Schiphol, may take away some traffic on short and medium haul routes, but at the same time it extends the catchment area of the airport.

3.2.2.1.3 Industry structure: The government tendered a concession to run trains on the HSL line to HSA, which is expected to pay the Dutch Government for the exclusive right to domestic transport on the high-speed line for a 15-year period. The track infrastructure remains the property of the Dutch Government, which pays an annual performance-linked fee to the infrastructure manager (Infra-speed Consortium) in return for meeting agreed availability targets.

3.2.2.1.4 Tendering and construction: The project was packaged and procured in two parts, the substructure (six contracts) and the superstructure (one contract). The key reasons for this separation were the expected inability of the construction industry to assume multi-billion-euro contracts, competition requirements, existing detailed substructure designs and an agreement with Belgium which put time pressure on the expected completion date.

3.2.2.1.5 Superstructure: (encompassing rails, electric system, telecommunications system, safety and signalling, sound barriers, balustrades and fences, facilities in the

tunnel buildings, emergency facilities, ventilation systems in the tunnels and long-term maintenance thereof) – The superstructure was procured using a PPP approach via a single availability based design, building, financing and maintenance (DBFM) contract. The Infra-speed consortium won the infrastructure provider contract after a European tender process with prequalification, an Invitation to Tender, negotiations and a Best and Final Offer stage. As part of the contract, Infra-speed guarantees 99.46 per cent availability of the line over the 25-year concession period from 2006 to 2031. As of 2006, the Dutch Government will pay Infra-speed an annual fee for making the HSL infrastructure available, which allows Infra-speed to cover its expenses, recover its capital investment and, subject to various contingencies, earn its anticipated IRR. Consistent with the approach adopted in Australian PPPs, the availability payment is subject to actual HSR network availability (i.e. if the consortium fails to realize 99.46 per cent availability, the fee is reduced)

3.2.2.1.6 Substructure: (includes structures, earthworks, etc.) – The Dutch Government took the view that it would be unable to successfully transfer the risks related to the substructure works and ground conditions, and decided that this aspect of the project would be best procured using a traditional D&C approach. The substructure was therefore contracted out to six engineering and construction consortiums with payments by the government during and upon completion of the engineering and construction phases. Although this type of contracting appeared to be integrated, detailed input assumptions that were not transferred, coupled with weak output definition, resulted in severe cost overruns and time delays.

3.2.2.1.7 Network connections: (awarded as a D&C contract) -The train operations and rolling stock supply were procured separately, with the separation of infrastructure and operations (awarded as a single train operations concession). Passenger transport was contracted out under a concession agreement to HSA**.** The contract did not work and was recently terminated and the incumbent Dutch Railways (NS) has taken control within their traditional mandate.

One of the main challenges of this framework was the management of interfaces between the various parties involved. To limit the complexity of each sub-project, the Dutch Government took the role of central counterpart, grouping similar types of risks while retaining the related interface risks between the various contractual arrangements.

Most of the risk was transferred to the private consortium except for demand risk and Infraspeed was remunerated on an availability basis, subject to any deductions for unavailability of the infrastructure and is independent of the level of traffic.

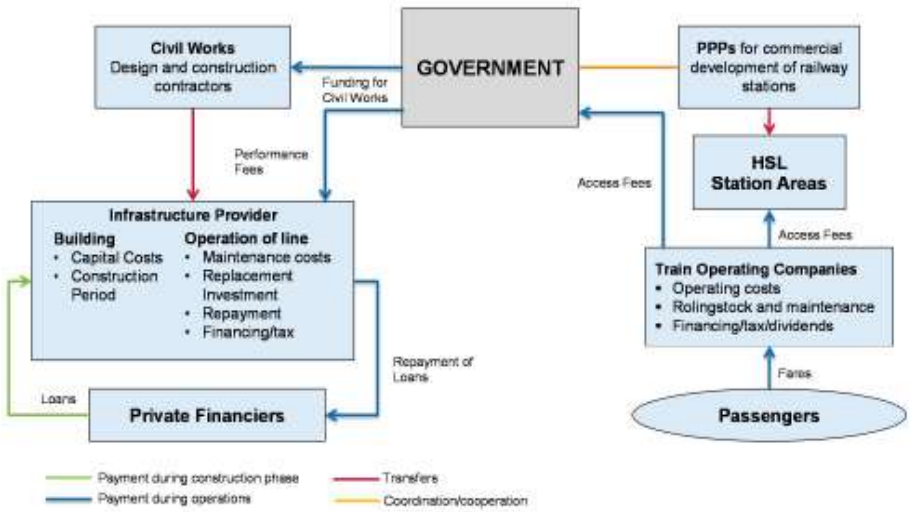
An access fee is paid by the operator to the government to gain access to the HSL stations and the rail infrastructure. The government used parts of these payments to fund the necessary civil works and pay a performance fee to the infrastructure provider. Also,

when needed, loans may be provided by private financiers to the infrastructure provider which is then responsible for making the repayments.

Services between Amsterdam and Brussels are offered by NS Hispeed (a subsidiary of HAS) and are operated by trains branded with the name Fyra39, while the existing operator Thalys40 operates between Amsterdam and Paris. Fyra and Thalys share the use of the high speed tracks in the Netherlands with all services coordinated through NS Hispeed. NS Hispeed facilitates the sales and operations of all high speed connection through the Netherlands. Head-to-head competition has not been a feature of the Dutch market.

3.2.2.1.8 Role of government: Even though the HSL-Zuid line was a PPP deal, it relied heavily on government funding, drawing on private investment for only 14 per cent (approximately €1 billion) of the project cost. The Dutch Government retained risks relating to the provision of the sub-surface works in the project. Market consultation undertaken by the Dutch Government revealed that the private sector was not likely to accept demand risk and this risk was therefore retained by the Dutch Government. According to a report by the Dutch Audit Commission, the State bore the resulting loss even though the construction contracts made the contractor responsible for the risks associated with the construction and maintenance of the network. The major financial risks remained with the State.

The HSL-Zuid project team was set up at the start of the project as a separate group under the supervision of the Ministry of Transport. However, no government agency had clear accountability for the execution of the project. Figure 3.2 illustrates the institutional arrangements for the HSL-Zuid Line.



Source: High Speed Rail Study phase 2 Report by AECOM

Figure 3-2: Role of Government - HSL– Zuid

3.2.2.1.9 Observations:

- The HSL-Zuid was regarded as an innovative and exemplary PPP project at the time it was launched due to the risk profile adopted. Despite its high profile as a PPP, however, the HSL-Zuid project relied mostly on public funding, drawing on private investment for only 14 per cent (i.e. about €940 million) of the project cost. From the beginning, a number of mistakes were made in terms of planning and risk management which undermined the success of the project.
- The demand risk (for operating contract) and infrastructure risk were retained by the Dutch Government. The Government also retained all rights with respect to operating, capacity utilization and tariff structure.
- The Dutch Government retained considerable risks relating to the provision of the subsurface works in the project to ensure that overall best value for money was achieved.
- Given the project was managed by two different government departments, there were issues with the project delivery and the procurement process. No government agency had clear responsibility for the execution of the HSR project.
- The level of unbundling during procurement and delivery phase increased interface risks but it also reduced the size of the contract, allowing the private sector to better assess risks associated with different sub-components.

3.2.2.2 United Kingdom – High Speed 1

3.2.2.2.1 Project background: Channel Tunnel Rail Link, or High Speed 1 (HS1) is a 108-kilometer HSR network that runs from Central London to the Channel Tunnel. In 1996, London and Continental Railways (LCR) was granted a concession to design, finance, construct, operate and maintain the HSR link. It was originally planned that the project would be privately financed; however, those plans were abandoned in 1997 after actual Eurostar revenues were found to be overly optimistic compared to prior projections. The private sector was now unwilling to take naked revenue risk on a greenfield rail project of this nature. The project was funded by a mixture of government grants and private funding by LCR. After LCR experienced financial difficulties, the United Kingdom Government stepped in and the line was transferred to government ownership in 2009. The LCR team delivered the physical project on time and on budget (£5.2 billion).

HS1 Ltd acquired the operating rights of the line in 2010 from the United Kingdom Government for a fee of $US3.4 billion. HS1 Ltd is jointly owned by Borealis Infrastructure and Ontario Teachers' Pension Plan, two Canadian pension funds. It holds the concession to operate, manage and maintain the infrastructure until December 2040. The United Kingdom Government, due to its ownership of LCR, maintains ownership of the infrastructure of the railway and the freehold of the associated land.

3.2.2.2.2 Objectives and intermodal competition: The line was built to carry international passenger traffic from the United Kingdom to Continental Europe, but it also carries domestic passenger traffic to and from towns and cities in Kent and has the potential to carry some freight traffic. The Eurostar services using HS1 faced strong competition and price wars from ferry and airline companies, which was one of the reasons that led to their shortfall in traffic volumes and average revenue yield, though there is strong evidence of optimism bias in the original forecasts.

3.2.2.2.3 Industry structure: The network is operated on a vertically-separated basis. As noted above, HS1 Ltd purchased the concessional right to operate, manage and maintain HS1 from the United Kingdom Government. It contracts out various functions including infrastructure management and passenger services. Domestic passenger services are provided by Southeastern, with Eurostar being the international provider. Eurostar is an open-access operator, operated jointly by the French (SNCF) and Belgian (SNCB) railways and Eurostar UK. Since government takeover of the line in 2009, the rail network has been owned, maintained and managed by Network Rail.

3.2.2.2.4 Tendering and construction: The original contract was awarded in 1996 to LCR under a target cost approach, with a Design Build Finance and Operate procurement model. However, following financial distress, the project was restructured in 1998 into two distinct phases under a Design-Build-Finance model:

Phase 1 – comprised the section which runs from the Channel Tunnel portal to north Kent. It was opened to passenger traffic on 28 September 2003 and was built at a cost of £1.2 billion.

Phase 2 – comprised the second and final section of the line which travels across the River Thames and into London St Pancras. It opened on 14 November 2007 and was built at a cost of £4 billion.

The funding structure of HS1 is summarized in Table 3.4.

Table 3-4: Funding Structure of HS1

Mode	Section 1		Section 2	
	£	%	£	%
Central government debt	2.65	69%	1.25	42%
Central government grants	0.70	18%	1.20	58%
Third party finance	0.49	13%	-	

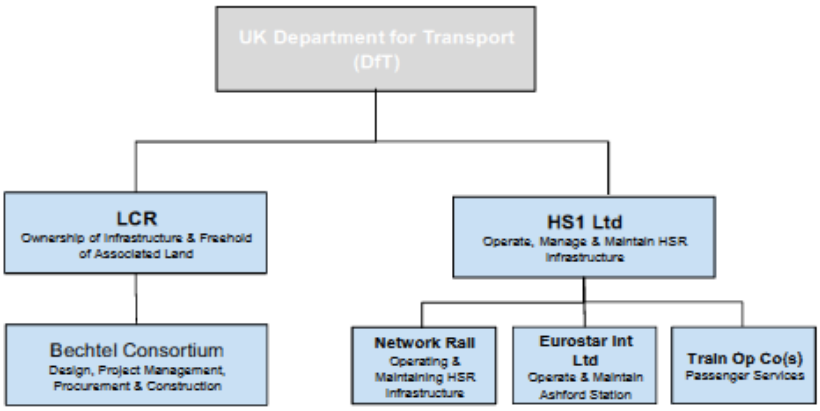
Source: California High Speed Rail Authority[43].

LCR faced further financial difficulties in 2009 and the United Kingdom Department for Transport (UK DfT) took direct ownership for a nominal price. This was possible due to the company's dependence on significant levels of government-guaranteed debt. In 2010, HS1 Ltd purchased the right to operate, manage and maintain the HSR infrastructure until December 2040 for £5.3 billion44. Network Rail is the contractor for maintaining and operating the railway infrastructure and three of the stations, namely St Pancras International, Stratford International and Ebbsfleet International. Eurostar International Ltd maintains and operates Ashford International Station.

3.2.2.2.5 Role of Government: In 1998, due to unrealistic traffic forecasts, LCR ran into financial difficulties. The project was subsequently restructured, with the government providing funding assistance in the form of grants.

Railways in Great Britain are privately operated but they are subject to control by the central government. Since 2006, DfT has run competitions for the award of passenger rail franchises, monitoring and enforcing the contracts with the private sector franchisees. Franchises specify the passenger rail services which are to be run in addition to quality and other conditions (e.g. the cleanliness of trains, station facilities, opening hours, the punctuality and reliability of trains, etc) which the operators have to meet. Some franchises receive a subsidy from DfT for doing so, while some are cash-positive meaning that the franchisee pays DfT for the contract. The Office of Rail Regulation (ORR) regulates HS1 through its concession agreement and the memorandum of understanding with the Secretary of State. The function of ORR includes pre-approval of the regulatory framework and ensuring that the HS1 has incentives to incur efficient costs and access charges. Other functions related to network regulation/asset management, monitoring and reporting and enforcement. Any disputes relating to the breach of the terms and conditions of the concession contracts are brought to ORR for arbitration rather than the court of law.

Institutional Arrangements for HS1.



Source: High Speed Rail Study phase 2 Report by AECOM

Figure 3-3: Institutional Arrangement for HS1

The roles of the key parties in the HS1 organizational structure are:

- **United Kingdom DfT**: The United Kingdom DfT was the procuring authority for UK HS1.
- **LCR**: LCR was originally granted a concession to design, finance, construct, operate and maintain the HSR project. LCR was privately owned at this stage, but in 2009 the United Kingdom DfT took direct ownership of LCR for a nominal price.
- **Bechtel Consortium**: The construction of HS1 was project-managed for LCR by a Bechtelled consortium, which was responsible for design, project management, and construction management of HS1. The consortium delivered the physical project on time and to budget.
- **HS1 Ltd:** HS1 Ltd holds the concession from government to operate, manage and maintain the HSR infrastructure until December 2040.
- **Network Rail:** Network Rail is a contractor to HS1 Ltd and following completion of construction, operates the railway infrastructure and three stations.
- **Eurostar International Ltd:** Eurostar maintains and operates Ashford International Station on HS1 Ltd's behalf including Eurostar International Limited which continues to own and operates the Eurostar train-sets running between London and European destinations.
- Southeastern hold a regional franchise serving domestic customers and pays access charges to HS1.

3.2.2.2.6 Observations:

- ORR regulates HS1 Limited through its Concession Agreement and a MoU with the State.
- The lessons learnt from the implementation and delivery of HS1 has led the United Kingdom Government to the realization that significant public sector involvement in projects of this size is inevitable.
- The government funded 87 per cent (in grants and debt) of Section 1 of HS1, and 100 per cent of Section 2 (refer to Table 3.4).

3.3 HIGH SPEED RAIL SCENARIO IN INDIA

3.3.1 Initiatives in India

In India, a thought for high speed operation was given in the first Governing Council Meeting (GCM) of RDSO in 1988 when it was decided to develop technology for operation of passenger services at 160 kmph on specified mixed routes and at 200 kmph on dedicated routes. A Task Force was set up in RDSO to study all the aspects of introduction of high-speed technology. In this connection, a feasibility study was conducted with the help of a Japanese Company (JICA) for Delhi-Kanpur section via

Agra (448 kms) to run the trains at 250 kmph. The report was submitted in 1987. JICA recommended setting up a new corridor with terminal stations at Delhi, Agra and Kanpur with an anticipated cost of Rs.2200 crores at 1987 price indices. Two types of services as given under were suggested in the study report.

Super express train at maximum speed to 250 kmph on new corridor of Delhi-Agra-Kanpur and

Long distances express trains operating at 160 kmph to utilize dedicated track with a facility of getting in and out of new corridor at Agra and Kanpur.

A traffic study was conducted on the following routes-

- Mumbai Vadodara-Ahmedabad (492 kms.)
- New Delhi – Kanpur – Lucknow (507 kms.)
- New Delhi – Agra (199 kms.)

Based on these detailed studies, Mumbai-Ahmedabad section was found having the best potential. However, cost being very high (Rs.4.9 crores per km. in 1987); if upgraded to the present-day cost. It would come out to be about Rs.50 crores per km. Board closed the mission vide their letter no. 98/ER/3400/21/1 dated 28.03.01 addressed to RDSO.

Indian Railway is now again considering going for high speed. The Integrated Railway modernization plan Nov.2004 for the period 2005-2010 envisages high speed trains running at 250-330 kmph. Ahmedabad-Mumbai corridor was specifically identified for the feasibility study. In this regard, RITES Ltd., has carried out a feasibility study and financial appraisal for Mumbai-Ahmedabad corridor. Now based on these studies, the project of Mumbai-Ahmedabad High Speed Rail has been sanctioned at a cost of Rs75450 crores initially and works are in progress. Revised estimated cost is likely to be higher. The line is targeted to be completed by 2024.

A few other projects, like this Kerala's Semi High Speed Rail project are under active consideration as given in the MOR's Vision Statement laid down in Parliament and are under various studies.

3.3.2 High Speed Rail projects in India

A few projects of importance and of recent development in India are reviewed more closely for studying the critical nature of these projects including their workability and viability and are explained as under.

3.3.2.1 Mumbai-Ahmedabad High Speed Rail Project

Study commissioned by the Ministry of Land, Infrastructure, Transport and Tourism of Japan in 2012 stated as under,

Characteristics of this study: The study decided to use standard-gauge new HSR lines (without the use of existing lines) for the following reasons:

- The majority of HSR of the world use standard gauge.
- The track capacity of the route's existing lines is limited.
- To the ensure operational safety of a railway of differing speeds

In addition, they studied carriages, signals, and other railway systems with focus on the Shinkansen, which has performed well in high-volume, high-speed operations for many years.

Maximum speed: Although the design maximum speed will be 350 km/h, they set the maximum speed in business operation at 320 km/h for the time being.

Study preconditions: The study's preconditions are provided in Table below.

Table 3-5: Pre-condition for Mumbai-Ahmedabad HSR

Item	Premise
Year of launch	2020
Section	Mumbai–Ahmedabad
Dedicated HSR line	Not intended for the operation of conventional trains or freight trains

Railway facility design standards: Table 3-6 shows the railway facility design standards used in the study. The construction gauge and vehicle gauge used in the study are provided in Figure 3.4, and a cross-section of an embankment, which is the main structure of the study, is provided in Figure 3.5.

Table 3-6: Standards for the Design of Railway Facilities: Mumbai - Ahmedabad Line

Item	Standard value (Provisional)
Gauge	1435 mm
No. of tracks on the main line between stations	2 tracks (double track, one direction)
Design maximum speed	350 km/h
Maximum operating speed	320 km/h
Minimum plane curve radius	Main Line : R= 6000 m Passing Track : R= 1000 m Car Depot etc : R= 300 m
Vertical curve radius	25000 m
Maximum grade	General areas excluding station：25‰ Inside station and side lines：3‰ （In principle: Level） Car depot, etc.：Level

Item	Standard value (Provisional)
Track center distance	4.3 m
Width of formation level	11.3 m
Cross-section of tunnel	63.4 m² (double track tunnel)
Maximum axle load	Less than 16 t
Track structure	Tunnels and bridges: Slab track Roadbed (embankment, cutting): Slab track or ballasted track
Feeding voltage	AC 2x25Kv
Overhead catenary system	Simple catenary system
Signaling system	Digital-ATC
Train control	Automatic train control, traffic control
Train radio	LCX (Leaky coaxial cable)
Rolling stock	Maximum 16 cars (capacity 1,280 persons)/ (2 stories, capacity 1,600 persons） Car width: 3.4 m

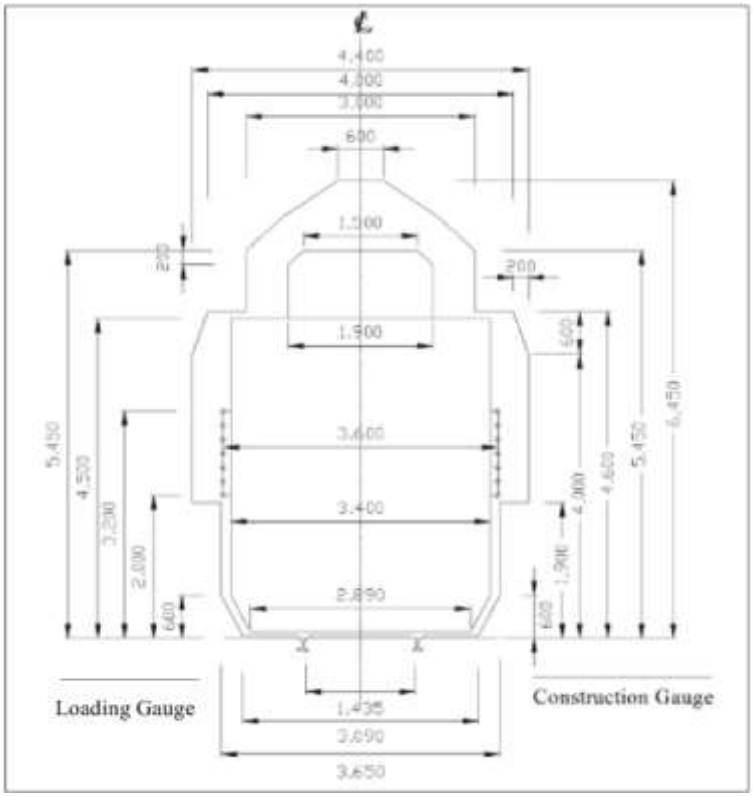


Figure 3-4: Cross-section of structure - Mumbai - Ahmedabad Line (provisional)

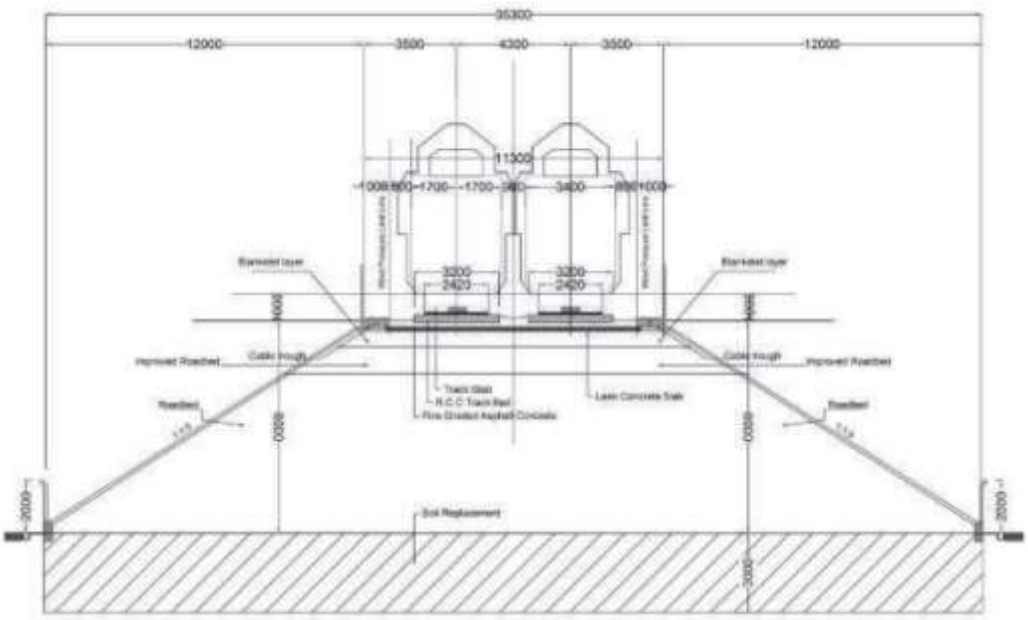


Figure 3-5: Cross-section of embankment - Mumbai - Ahmedabad HSR

Route plan: The Mumbai–Ahmedabad section is a long line with a total length of 500 km. In view of the distribution of cities on the line, study has determined that the line would have 11 stations, with an average of 50-km interval between them. The study also put together a significant cost reduction proposal that would drastically reduce the project cost. In the significant cost reduction proposal, the Thane station in the original proposal will serve as the Mumbai station and no Mumbai station will be built. The Ahmedabad station will not connect to the existing station but it will be built in the suburbs to reduce the project cost.

Demand Forecast: Looking at demand estimates for HSR being discussed here, estimates for the original proposal show that the maximum cross-sectional traffic volume for the section will be approximately 25,300 passengers/day (both directions, commencement of service in 2020) to approximately 199,000 passengers/day (both directions, 2050), while estimates for the vastly cheaper proposal show that the maximum cross-sectional traffic volume for the section will be approximately 21,300 passengers/day (both directions, commencement of service in 2020) to 178,000 passengers/day (both directions, 2050). It should be noted, however, that the access and egress time of high-speed railway stations from city centres of the vastly cheaper proposal do not take the effects of traffic congestion and other factors into account.

Fare-Setting: When setting fares, the study conducted estimates based on an analysis of the fares that would generate the maximum amount of fare revenue from the fare-demand relationship using the results of a “Stated preference” (SP) survey (survey of degree of preference by passengers of selected transport modes) that was conducted within another study (other route) in India.

Project Capital Cost: The project cost under this plan is Rs.754.5 billion (at the time of service commencement). The per-kilometer cost of the project is estimated to be Rs.754.5 billion / 498.52 km = Rs.1.513 billion per kilometers.

In the case of the vastly cheaper proposal*****, the project cost Rs.542.9 billion (at the time of service commencement). The per-kilometer cost of the project is estimated to be Rs.542.9 billion / 448.2 km = Rs.1.21 billion per kilometer.

It should be noted that import duties and value-added tax, which were not include in the project cost of the 2009 pre-feasibility study (India), are similarly not calculated in the project costs of this study.

***** The vastly cheaper proposal does not consider placing the Mumbai station in the city centre, but rather makes the Thane station of the current plan the terminus for the Mumbai metropolitan area. Moreover, for the Ahmedabad station, it does not envisage line extension to the existing Ahmedabad Station, but rather will establish a terminus for the Ahmedabad metropolitan area at a location outside the Ring Road. Consequently, it will be necessary to separately develop means of linking these high-speed railway stations with the city centers. The proposal makes no particularly noteworthy changes regarding the intermediate stations.

Economic Analysis: The EIRR, NPV, and CBR for this route are calculated as follows on table 3-7,

Table 3-7: Economic analysis of Mumbai - Ahmedabad HSR

Route	EIRR	NPV	CBR
Route 1	18.7%	Rs 360,250 million	1.98

Because the EIRR of the surveyed route will exceed the 12% opportunity cost of capital in India, this project was confirmed to be beneficial to the economy and society.

Financing Plan and Project Model: Table 3.8 shows the two basic cases for review in this Study:

Table 3-8: Financial options of Mumbai - Ahmedabad HSR

Project scheme		Superstructures	Substructures
1. Two-tiered (public project)	Entity	Public	Pubic
	Funding Source	Yen Loan	STEP
	Entity	Public	Private (+Public)

2. Two-tiered (superstructures: PPP, substructures: public project)	Funding Source	Yen Loan	Project Finance

The following are main results of the study:

(i) Separation of Superstructures and Substructures (Public Project) The Project FIRR became 1.6%, which exceeded the interest rate shown in the Japanese ODA loan conditions table for low-income countries. In addition to yen loan, this approach can also use STEP. This will make the financing cost the lowest among the two cases, making it easy to implement the project. It is the ideal case but the concerned parties must share the risks.

(ii) Separation of Superstructures and Substructures (Superstructures: PPP, Substructures: Public Project) For the superstructures, the Project FIRR (8.0%) is lower than the WACC (8.7%), making the approach not viable as a PPP project. To obtain project finance, the concerned parties must share the risks appropriately. The availability payment method shall be considered but the SPV must not bear any demand risk. The use of project finance will make the financing cost the highest among the two cases mentioned above.

3.3.2.2 Delhi-Meerut Regional Rapid Transit System

DPR prepared by The Delhi Integrated Multi Modal Transit System (DIMTS) for RRTS-Delhi-Meerut stated as under,

Objectives of study: The vision of RRTS can be summarized in the following points:

- To create a hi-speed, high capacity, transport system having predominantly seated accommodation and good comfort level for passengers.
- The operating pattern may include both non-stop and stopping at all stations journeys. The journey between Delhi and Meerut to be in the order of 60 minutes for the RRTS corridor.
- The Delhi terminus shall be integrated with the existing Delhi Metro network including the development of feeder systems.
- Optimized locations of stations for ease of access to commuters and to serve maximum volume of ridership.
- Optimize route and number of stops so as to achieve good operating speeds.

Maximum speed: The RRTS will have standard gauge track fit to carry 17 tonnes axle load. The operational speed of trains will be 160 kmph with a design speed of 180 kmph and so the track should be fit for these speeds.

System Selection:

Table 3-9: System Parameters of Delhi-Meerut RRTS

Item	Standard value
Gauge	1435 mm
Traction power	25 KV, 50Hz overhead line
Regenerative braking	Provided
Vehicle length considered for calculation (This may vary as per system requirement at time of implementation)	22 m
Axle load	17 Tonnes
Train lengths	6, 9,12 cars
Maximum speed	160 kph. Design speed 180 kph
Ruling gradient	Maximum gradient of 1:100 (compensated) on the elevated viaduct portion of the track. The compensation will be at the rate of 0.04% per degree of curvature. On the switch over portion from underground to surface, the maximum gradient permissible has been kept at 1:33.
Curves	Vertical curve shall be provided only at the junction of grades when the algebraic difference between the grades is equal to or more than 0.4%. It is suggested that the minimum radius of the vertical curve shall be 4000 meters. Horizontal curves should be of minimum 1500 meters radius for a speed of 160 Kmph.
Turnouts	For riding comfort and ease of maintenance, it is proposed to have 1 in 9 canted turnouts with curved switches and weldable crossings on main line as well as loop lines. The rails for turnouts shall also be UIC 60 head hardened rails to grade 1080. The speed of

Item	Standard value
	the train will be restricted to 50 Kmph on such turnouts.
Rails	It is proposed to have Continuous Welded Rails (CWR) for the RRTS. The rail is recommended to be UIC 60 head hardened rails
Track structure	Ballast less track is recommended on the elevated viaduct and underground tunnels.
Signal and Train Control	The CATC based signaling system has been proposed to meet design headway of 2 minutes.

Route Plan: The total route length of the RRTS alignment is 92.05 kms with 11 elevated and 6 underground stations including Nizamuddin/SKK. The terminal stations are Sarai Kale Khan and Modipuram on the main line and Shastri Nagar on the spur line. On account of traffic requirement mid terminals have been planned at the Guldhar and Meerut South station.

Integration has been provided at Sarai Kale Khan/Nizamuddin station for smooth transfer with the Alwar RRTS and DMRC Phase-III corridor. Emergency cross overs have been provided at Sarai Kale Khan, Sahibabad, Guldhar, Duhai, Meerut South, Modipuram and Shastri Nagar.

Demand Forecast: The passenger forecasts have been derived under assumptions of feeder network and Transit Oriented Development together with simulated travel time and fares as per willingness to pay survey. This is based on 62 minutes travel time between Sarai Kale Khan - Meerut, peak and off-peak frequency as per operational plan and fare as determined from Willingness to pay surveys. The forecasted ridership is presented in Table 3.10. The fare from Sarai Kale Khan (Delhi) to Modipuram station has been considered at Rs. 160 based on total length of the corridor.

Table 3-10: Traffic estimates of Delhi-Meerut RRTS

S. No.	Year	Ridership per day
1	2021	742,332
2	2024	795,516
3	2031	919,612
4	2041	1,135,530

In addition, an analysis was conducted to delineate the Transit Oriented Development zones near to the various stations. The extra development and inducement of traffic from finalized TOD zones and due to reduction in transport cost was accounted for in the traffic forecasts.

Fare-Setting: For the proposed RRTS system dynamic pricing strategy has been proposed which would allow RRTS capacity to be more efficiently rationed by relieving crowding during the peak hours while helping to make optimal use of the spare capacity during the off-peak periods.

Considering the above factors an average fare of Rs 160 (at November 2016 levels) is proposed between Sarai Kale Khan Station and Modi Puram station.

Project Capital Cost: The overall Capital Cost for the RRTS corridor at current price level (2016) works out to Rs. 219,025.48 Million.

Economic Analysis: Economic viability of the proposed RRTS project has been assessed within the broad framework of "Cost-Benefit Analysis", generally used for appraisal of public investment projects.

The benefits of fuel cost savings, time savings due to increased speed and environmental and accident are added together to get the total savings. The rate of return considered desirable for the transport infrastructure project in India is 12 percent. As EIRR of proposed **RRTS facility is 19.81 %,** which is above 12 percent cut-off rate, the project is considered economically viable.

Key Revenue Avenues: The project revenue has been estimated from following broad categories namely:

- Fare Box revenue; and
- Other Sources of Revenue
    - Revenue from Rentals (inside the Stations);
    - Revenue from Property Development
    - Revenue from sale of Advertisement Rights; and
    - Property Transaction Cess on Transit Oriented Development area
- Additional Fund Mobilization measures
    - Sale of additional Floor Area Ratio (FAR) in influence zone
    - Levy of additional Stamp Duty
    - Levy of additional Development Charges

Financing Plan and Project Model: Following implementation options are available:

1) Option A: Deliver Entire Scope of Work by NCRTC.
2) Option B: Design Build Finance Operate and Transfer (DBFOT) model.
3) Option C: Infrastructure by NCRTC and Systems & Operations by Private sector Partner.

3.3.2.3 Kerala HSR Project between Thiruvananthapuram and Kannur (Studied by DMRC)

The salient features of Detailed Project Report submitted by DMRC (which incidentally is on the same route) is mentioned in Table 3.11.

Table 3-11: Systems Parameters of Kerala HSR Project

Item	Standard value
Gauge	1435 mm
Route Length	430.0 kms (Dead end to Dead end)
Design maximum speed	350 km/h
Maximum operating speed	350 km/h
Viaduct (10 kms Major Bridge for water way)	180 kms
Tunnel (Underground)	105 kms
No of Stations & Type of structure	9 Nos (5 Nos Elevated & 4 Nos At Grade)
Traffic Forecast	Y 2020: 80,942 Y 2028: 121,462 Y 2040: 173,390 Y 2051: 218,894
Track Structure	Ballast less Track for main line and Ballasted track in Depot except washing line and inspection bays
Min Curve Radius	6250 m
Min Longitudinal Curve Radius	25,000 m
Max Cant	160 mm
Max Gradient (1/1000)	25o/oo
Distance between Track Centres	4.5 m
Car Width	3.4 m
Max. Axle Load	19 Ton (Design with UIC Loading)
Width of Track Formation	13.7 m
Tunnel Cross Section (Standard Double Track)	90 m^2

Item	Standard value
Train Operation	Every 15-20 minutes in peak hour (06.00 hrs to 10.00 hrs and 17.00 hrs to 20.00 hrs.). In non-peak hours the trains at interval of an hour The train operation plan has been taken for headway of 10.75, 10.75 and 9.0 minutes in the year 2028, 2040 & 2051 respectively during the peak period
Traction Power Supply	2X25 KV AC
Rolling Stock	8 coach: 560 passengers 12 coach: 840 passengers
Signaling System	ETCS (European Train Control System) level - 2 based on GSM-R Radio Communication with Continuous Transmission of Permanent Movement Authority, Cab Signaling & Continuous Automatic Train Control with Automatic Train Protection.
Telecommunication System	Train Radio GSM-R based, Fiber Optic Transmission Backbone, SDH over Ethernet, Integrated SCADA, Passenger Announcement System, Passenger Display System Control Telephones and Centralized Clock System.etc
Estimated Capital Cost (at March 2015 base)	Rs. 90663.05 Crores (inclusive of land).
Proposed Fare	Rs. 5 per km in Standard Class Rs.10 per km in Business class.
Financial Internal rate of Return (FIRR)	4.67 %
Economical Internal rate of return (EIRR)	14.02%
Financing Options	1. Build, Operate and Transfer (BOT) 2. Public Private Partnership (PPP)

Item	Standard value
	3. Fully through Government funding. That is Government to mobilize all the funds through equity, grants and debts (borrowings with government guarantee).

The above projects review clearly indicate the standards, methodologies, cost levels, funding options, revenue sources and their level of financial and economical viability. They serve a good guidance for deciding on the critical project requirements for the Kerala's semi High Speed Rail Corridor project. It could be seen clearly that these modern and high speed high capacity system projects have gone for Stand Alone Rail based lines with Standard Gauge and latest high-end technology based Engineering, Rolling stock, Power, signaling, Operation and Safety systems for such lines.

3.3.2.4 Suburban Rail Project between Thiruvananthapuram – Chengannur

To meet the needs of the huge volume of commuter passengers, Government of Kerala had proposal to operate Suburban train services in Thiruvananthapuram – Chengannur /Haripad sector in Phase – I with air conditioned MEMU/EMU rakes. M/s Mumbai Rail Vikas Corporation (MVRC) has finalized the Detailed Project Report. The total cost of the project is 3,300 Crore. A Special Purpose Vehicle was formed between Government of Kerala and Indian Railways with 50:50 equity participation for taking up the implementation of the project. -**The project did not take off further as Govt of India issued new Suburban policy required additional two lines to be provided in the sector for taking up suburban services.**

3.4 KERALA'S PLAN FOR A FAST AND COMFORTABLE RAIL BASED SYSTEM

3.4.1 Vision and Policy

Vision **-** The vision of the Government of Kerala in Transport sector is for **"Shaping a modern, efficient, economical and safe transportation system, connecting various growth regions in the State, to meet the faster mobility needs of all Keralites by 2025"**

The mission GoK will endeavor for taking concerted, continuous and long term efforts for **"achieving safe, economical and fast transport system for moving people and goods in the State by integrating different modes of transport according to their**

economic advantages with respect to cost, speed, low carbon emission and travel comforts".

These above mission will be achieved by improving connectivity to upcoming growth regions in the State through inter-modal transport planning, and proper implementation of projects and schemes worked out based on the proposed characteristics of inter-state, inter-district and intra-city transport demand of people and goods in the State and their ideal modal share. The trend of urbanization, land use changes, the growth plans of different sectors of the economy, the inherent strength and weaknesses of different modes and transportation system with special reference to their sustainability, efficiency, employment generation, productivity, resource and social cost etc. will be taken into account for intermodal planning.

Transport policy Statement

The present transportation system in the State was evolved by piece-meal process, which remains under connected and uncoordinated. It is characterized by high operating cost, inefficiency and high accident risk. The situation is likely to worsen in future due to increase in population, urbanization and demand for personalized transport resulting from economic growth and higher income. The daily transport demand is expected to grow from present 135 lakh trips to over 180 lakh passenger trips by 2025.Kerala will continue to remain as a consumer market for all kind of goods. The existing transport system will not be able to cater to this much demand and hence the inter-modal goods transport system, mass transit system, urban transport infrastructure, traffic management and associated amenities must be improved substantively.

The overall objective of the Transport Policy is to evolve schemes to meet, in a phased manner, the requirements of faster mobility, safety, access to social and economic services and minimizing the impact of negative externalities.

Objectives and Strategies:-

A. Objectives

- To revamp public transportation system to increase its share from existing 33% of total passenger traffic to 80 % in 2025.
- Reduce dependency on personal transport and increase share of railways in inter-state and inter-city transport and that of buses in intra-State and intra-city transport.

B. Strategies

- **Inter-city transport:** The government will encourage rail based public transport system for inter-city travel which is cost effective and environment friendly. In order to strike the appropriate modal balance between public transport and personalized transport, public transport system that is used by common mass will get maximum attention of the Government. Encouragement will be given for investment in rail-based metro or mono rail

systems in congested inter-city routes and **introduce High-speed intercity passenger rail service and sub-urban rail system on main line routes.**

3.4.2 Plan for Higher Speeds in Railways and Development of Semi High Speed Rail Corridor

Suggested Action Plan for Railways: The present rail transport system in the State is weak and exhausted the installed capacity and there is already excess demand resulting in long queues and associated discomfort in travel. The average speed of Express trains running in the State is below 45-50 kmph. Railway should device plans to introduce Mainline Electrical Multiple Units (MEMU), between major intercity routes with latest electronic passenger information system and engines on both sides to enable it to start like bus.

There are proven technologies developed in the world, whereby the trains can operate at the speed of 150 to 200 km. per hour. If such high-speed technology and tracks are introduced in the State, the spatial separation of Kerala and the north-south divide can be reduced, and the travel time brought down from the present 10-12 hours to 4 hours. The State Government will provide all necessary support for the new high-speed corridor including provision of required land free of cost.

Advance actions and necessary surveys should be initiated by the K-Rail for finalizing the alignment for the new facility so that the necessary land can be frozen from alternative developments which demand is pressing in the State. If advance actions are not taken at this time, there will not be any land available to lay such tracks in future and such tracks have to be laid on elevated corridor at cost 100 times more than the present cost.

Kerala State's Action Plan: The project of **Thiruvananthapuram-Kasaragod Semi High Speed Rail** is being proposed under the **HSR policy of Govt of India where the route of Chennai-Bangalore-Ernakulam- Thiruvananthapuram has been identified at item no 5 as shown in table 1-1.** As the prevailing traffic in the Thiruvananthapuram-Kasaragod section of Southern Railway is substantially high, and this being the main feeder route for the identified HSR route, this stretch has been selected for the project in first priority. As & when the need is felt, other sections forming part of the identified route in the GOI's policy will also be prioritized and proposed.

Further in view of existing heavy commuter traffic in trains & roads from the cities and towns which are located in close vicinity to the main commercial cities such as Thiruvananthapuram, Ernakulam, Thrissur, Kozhikode & Kannur and in view of the fact that the population and developments in the State are evenly & linearly distributed, this project also gets importance and priority for consideration under the **GOI's latest policy**

for taking up New Suburban Rail System on Indian Railways, in MOR's letter No.2016/Proj/Policy Matter/4/2 dt.17-8-2018.

Under the policy guidelines referred above, a Feasibility Study has been conducted for Semi High Speed Rail Corridor from Thiruvanthapuram to Kasaragod by M/s SYSTRA MVA Consulting India Pvt Ltd & after getting nod from Government of Kerala, the same was submitted to Railway Board for their approval. MoR has accorded their 'In- Principle' approval and has directed to take up the DPR and other 'pre-investment' works for further proceeding with development.

Govt of Kerala, hence taking all the above in to account, has initiated the project of High Speed Rail Corridor services in the State and proceeded as discussed already.

3.4.3 Challenges to the introduction of Semi High Speed Rail in Kerala

Based on past experience of similar projects (though smaller in size) and on the detailed knowledge about the State (its resources and capabilities), etc, a study was made to identify the critical issues likely to come in the way of implementation and progressing of the project and the outcome are brought out below.

Coordination and cooperation: The Kerala Semi High-speed Rail corridor, being a green field project, may have long gestation period and will be highly capital intensive. Thus, a strong will, consensus and strategic thinking is required at the apex level for implementing it in a programmed manner in view of the merits and importance of this project for Kerala. As expected, as in case of any huge infrastructure project, funds requirement, land acquisition and inter departmental issues become critical in execution of such projects. Various government departments and agencies shall be required to work for the project. A good coordination among various departments of Central Government and State Government is a must for the successful implementation of the project.

Land Acquisition: Land acquisition is critical in SilverLine project due to its stringent alignment requirements. As SilverLine corridors pass through conurbations and or sensitive land, public protests are to be dealt with carefully by implementing agencies. So, a correct mix of alignment choices between grade/ elevated/ tunnels is a must.

If K-Rail feel appropriate, there could be a new approach of participatory land acquisition coupled with negotiated purchase, where in the land owner is treated as an equity holder of the project rather than a disposable entity owning a parcel of land.

Environmental issues: Unique to Kerala, it has two rainy seasons. They are the southwest monsoon and the Northeast monsoon. The southwest monsoon, *Edavapathi* (in *Edavam Malayalam month*) comes in the month of June and the Northeast monsoon, *Thulavarsham* (in *Thulam Malayalam month*) starts in mid-October and finally ends around mid-November. The monsoons in Kerala do not take the form of incessant rain over days and weeks. The typical pattern is that it rains for a few hours followed by interludes of sunshine, leading to alternate wetting and drying of track and fittings. These monsoons shall create problems of flooding if the low-lying lands are filled up for the project. This situation is to be avoided and hence the consultants have tried to avoid filling up the paddy fields for stations and alignment, to the extent possible. Another issue related to the monsoon is the drainage of water along the SilverLine corridor. The continuous embankments and viaducts along the corridor, shall collect a lot of rain water like an umbrella and these needs to be properly drained to avoid flooding and to keep the embankments safe. One way to mitigate this problem would be to make water bodies like small ponds along the corridor, like the temple/*kaaavu* ponds Kerala had in the near past. Another issue with the monsoon is that it creates alternate wetting and drying conditions for the tracks and fittings and concrete (of via duct). The track fittings could get loose, rust, etc. affecting strict maintenance tolerances of track and fittings. So, a robust **RAMS** (*Reliability, Availability, Maintainability and Safety procedure*) may be adopted for construction and maintenance of the corridor.

Safety issues along the corridor: The recent floods in Kerala, the Okhi cyclone and the Kasturirangan/ Madhav Gadgil reports on the western Ghats Ecology, etc. have all created certain questions among the public about safety of these kind of infrastructure projects. The project planning should take care of the natural safety hazards of landslides, flooding, drought, Tsunami, etc. along the corridor.

Lack of quality construction material/contractors: Cement, metals (steel mostly), embankment and moorum earth and mineral aggregates in the form of coarse aggregate, fine aggregate (sand), track ballast are required in train/ truck loads for this project. The quantum of materials required for this project has not been calculated at this level of study, but one can normally appreciate the huge volume required for a 529.45 kms Rail corridor project. From recent experiences of Railway doubling projects and strict vigilante mode of quarry control in the State, it is almost certain that Kerala alone will not be able to satisfy the material requirement for this project especially when the construction period is set for 7 to 10 years. Unfortunately, negative publicity, arising mostly out of ignorance and partly motivated, is a reality for all these infrastructure projects. It is also “gossiped” that agencies competing for a pie in the project also create negative publicity for the technology/ methodology of the project. To mitigate this problem, regular and controlled dissemination of information regarding the project is essential. K-Rail may employ the

services of a PRO agency for the project, to create public awareness and necessary support from the public.

Policy framework: Robust policy framework is required for the seamless implementation of the project. The policy framework shall ensure that the various stake holders of the existing system may work in tandem resulting from the integration of this new rail-based corridor into the system. Seamless integration is the result of careful planning which should start during the design phase of the project. Towards this, along with the client K-Rail, the consultants shall interact with the various stake holders listed below. Seamless integration shall also assure the public and investors of the project.

Stake holders: The list of potential stake holders for this project is given below in table 3.12 and may have to be revised in future. It would be beneficial to the project if more stakeholders, who can generate revenue to the project, is brought in for the financial viability of the project.

Table 3-12: Stakeholders and their Responsibilities

Sl no	Stakeholder	Role Contributed	Involvement
1	K-Rail	Project Team	High
2	SPV (for execution)[1]	Project execution	High
3	GOK	Investment in the Project, land	High
4	Indian Railway	Joint venture investment with GOK/ investment in the project	High
5	Corridor Land owners	Due to land acquisition	High
6	Funding agency	% Total investment, Financed through loan	High
7	Passengers	Project Users	High
8	MPs, MLAs, Local bodies	Public opinion, negotiation, waste management	High
9	Media	Public Information	Medium

[1] Ref K-Rail report page 41

11	Environmental Clearing agencies	K-Rail needs to get Environmental Clearances wherever required	Medium
12	Companies Contractors	Construction & Operations	High
13	Revenue department	Land acquisition/ development	High
14	State PWD	Project connectivity, maintenance, Corridor ROW development (tentative)	High
15	Inland Navigation department	Integration with the corridor/ land development	Medium
16	Plantation corporation	Land parcel, if required for the project	High
17	IT department	Generation of revenue to SPV	High
18	Oil companies	Generation of revenue to SPV	High
19	Advertising Agencies	Generation of Revenue for SPV	Medium
20	KSEB	Power supply and transmission, cabling	High
21	Water and waste Water department	Maintenance of sewage system and garbage	High
22	Kerala Police	Maintaining law and order during construction, operation & parking	Medium
23	Smart city projects/GOK	Development of smart cities along the corridor	High
24	SYSTRA MVA	Research for the project and DPR	Medium
25	NGOs	Concern about the local community	High
26	Environmental and Pollution Control Board	Research on the project & its impact on environment	Medium
27	Local Communities & Villages	High Concern about the effect of the project	High

28	CISF	Safety and Security	High
29	Agricultural department	Due to alignment crossing agricultural fields, drainage issues and water body	Medium
30	ALIND	If land used by the project	High
31	FACT	If land used by the project	High
32	Defence Department	As SILVERLINE corridor is going close to defence establishments & necessary clearances will require.	High
33	Local district administration	During construction, necessary support will be required from local administration.	High
34	Mining Department	For Construction material, necessary clearance will be required from local mining department.	High
35	Labour Welfare Department	During construction & as well as functional stage, huge manpower will be engaged & necessary compliance of State labour laws must be applicable.	High

3.5 METHODOLOGY OF PREPARATION OF DETAILED PROJECT REPORT

Based on the Govt of Kerala's and Govt of India's approval and decision to take up preparation of DPR for the project and pre-investment activities explained earlier, M/s SYSTRA has been entrusted by KRDCL(K-Rail) with the preparation of feasibility report followed by Detailed Project Report for the corridor. Methodology followed in similar such international and Indian studies was adopted for DPR preparation.

This included the following reviews, studies, modelling and analysis:-

i) Reviewing of all available data on the subject of transport needs of Kerala, policies of Govt of Kerala and Govt of India, reports and data on various high speed railways in India and abroad in operation and planning, standards for adoption, economics of various systems, etc.

ii) Conducting Traffic and Transportation surveys at identified locations and considering all modes of transport (passenger and goods). Surveys includes-

- Reconnaissance survey,
- Classified Traffic Volume Count survey
- Origin & Destination survey,
- Public transport terminal surveys,
- Operator Surveys
- Willingness to Pay and willingness to shift survey,
- Stated Preference survey.

And assessing mode shift using mode choice modelling, estimating traffic growth for the horizon year, estimated daily ridership, fare sensitivity analysis etc.

iii) Conducting Engineering studies on ground along the planned alignment(Feasibility Report) such as-

- Topographical survey by Aerial LIDAR method to make Topo plans, Index plans and sections, Working plans and sections, cross sections, ground details, etc,
- Geotechnical survey with boreholes by sampling soil and conducting soil testing,
- Land surveys and displacement and rehabilitation requirements,
- Other ground studies as required,

iv) Conducting Environment Impact assessment studies covering-

- Environmental studies, restoration and rehabilitation requirements, etc.

v) Selection of Rail Systems and Standards for-

- Planning parameters for Gauge, Schedule of dimensions, curves, gradients, and other ground features,
- Alignment which is economically prudent and realistic for the project based on system parameters selected and ground features surveyed keeping the philosophy for alignment as under-
  i) selected alignment should provide the best connectivity to the cities and activity centres,
  ii) it should avoid heavily built up areas and heavy habitations to keep the displacement of house-holds and occupation of productive wet lands to the minimum,
  iii) it should be on generally simpler and reliable structures keeping tunnel, viaduct, bridge lengths low as far as possible keeping the extent of land requirements to the minimum,
  iv) it should help in reducing the cost of initial procurement and construction as well as the cost of operation and maintenance later.

- Engineering structures including track, stations, etc,
- Rolling Stock,
- Power Supply and Traction systems,
- Signaling and Train control systems,
- Operation system with philosophy for operation,

v) Estimating, Costing and Financial analysis in terms of-

- Realistic Project Cost estimate,
- Operations and Maintenance Cost estimate,
- Financial analysis to assess Financial and economic viability.

vi) Working out Implementation Scheme for Funding, Procurement and execution, Testing and commissioning and Operation and maintenance of SilverLine.

3.6 REFERENCES & GUIDELINES TAKEN FOR THIS CHAPTER

- A resource book on High Speed Rail Technology compiled by Mr Gaurav Agarwal, Director (Efficiency & Research)/Mech Engg. Ministry of Railway, Govt of India.
- Construction & Maintenance of High-Speed Railway published by Indian Railways Institute of Civil Engineering (IRICEN).
- Railway Vision Documents 2020.

DETAILED PROJECT REPORT

SEMI HIGH SPEED RAIL CORRIDOR
THIRUVANANTHAPURAM TO KASARAGOD

VOLUME II - MAIN REPORT
(PART A)

CHAPTER 4
TRAVEL DEMAND FORECAST

4 TRAVEL DEMAND FORECAST

As part of the DPR Study of Semi High Speed Rail (SilverLine), connecting Thiruvananthapuram and Kasaragod, detailed study of existing transportation system and travel characteristics of Kerala State has been undertaken. Information on the demographic and Socio-Economic factors, influencing the travel pattern have also been compiled. Review of earlier traffic studies have been carried out, along with the methodology adopted and salient findings. The same is summarised in this section.

This section of the DPR provides the details of primary and secondary traffic surveys and ridership forecast of SilverLine for different horizon years.

4.1 STUDY AREA PROFILE

4.1.1 Introduction – The Study Area

Kerala, the greenest State, located on the Southernmost tip of India, blessed with excellent tropical weather and networked by 44 rivers, 34 lakes, canals, ponds, and paddy fields, is popularly known as *God's Own Country*. This lush green strip of land lying between the Arabian sea and the steep Western Ghats has an area of about 38,863 Sq.Km and is inhabited by about 33.41 million people as per 2011 Census.

Kerala stretches for about 580 km along the Arabian Coast, varying in width from roughly 30 km to 120 km. It is bordered by the States of Karnataka in the north, Tamil Nadu in the east and Arabian Sea in the west and south. The administrative capital of Kerala is Thiruvananthapuram, which is a major destination for tourists. Kochi and Kozhikode are the other two major cities with lot of industrial developments.

The proposed SilverLine project envisage Semi High Speed Rail connectivity between Thiruvananthapuram and Kasaragod, with intermediate stops at key economic centres of the districts, such as Kollam, Kottayam, Ernakulam, Thrissur, Calicut, Kannur etc. **Figure** 4-1 given below presents the study area map of the proposed SilverLine project and its indicative alignment.

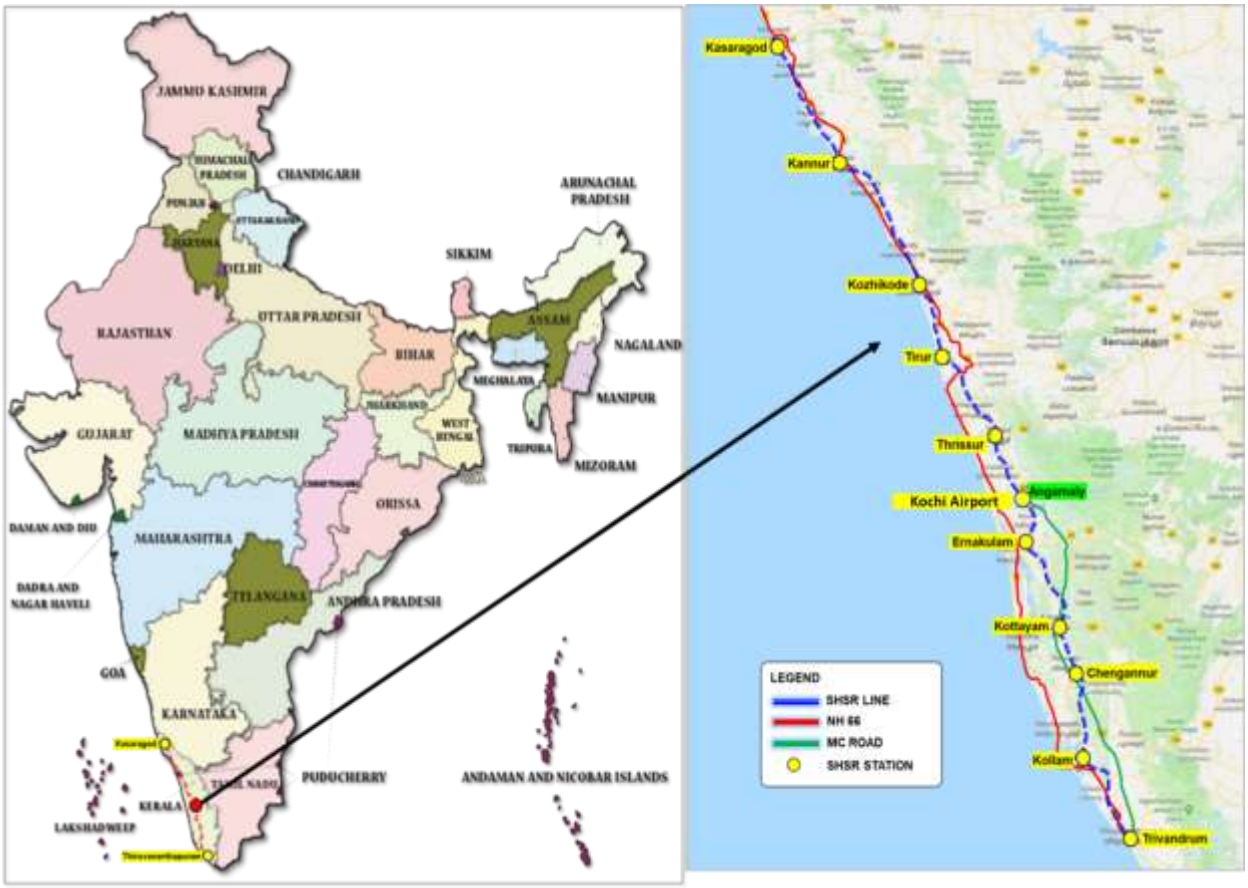


Figure 4-1: Study Area.

The major competing highway running almost parallel to proposed alignment is NH66. Another competing highway is Main Central Road (MC Road) which starts at Kesavadasapuram in Thiruvananthapuram district and ends at Angamaly in Ernakulam district. M C Road is parallel to proposed SilverLine alignment up to Ernakulam.

4.1.1.1 Rationale for SilverLine Station Locations

Public transport terminals such as Railway station or inter-state bus terminals have always been places of central importance in the structure of a city through which people orient and identify themselves. Key in this role, is the location of the transit nodes. As evidenced by the locations of railway stations in Kerala, these have generally been in the centre of the city that allows it to not only serve its role in terms of place making but also satisfying ideal transit requirements of even dispersal to the city while doubling as an interchange point.

However, as cities have developed in size and population, practical issues of land availability and congestion adversely affecting accessibility has made newer transit nodes to be shifted to the suburbs of the city. While this has served the transportation purposes of railway stations & bus terminals in terms of easier accessibility for rail and buses, it has almost reduced the role of terminal as a node.

Considerations:

There are a number of considerations in deciding the best location. The location should be where routes should logically connect or terminate, as determined by passenger demand patterns. If the station is used as an intermediate stopping point on routes passing through, it should be conveniently located for passengers joining or leaving vehicles. New transport terminals are also located outside central areas to avoid high land costs and congestion. But this shall be conflicting with increasing dispersal trip length within the city which causes inconvenience to users. So, the parameters for selection of station location can have different dimensions with regards to perspective of SilverLine commuter and SilverLine operator.

To determine the location for a new bus terminal, the following indicative criteria are considered. Depending on the project objectives and complexity the criteria can be adopted. They are:-

a) Distance from Catchments (Average Trip Length of Pax within City) – mainly user perspective
b) Scope of Multimodal Integration (Other Modes within walking distances) – user perspective
c) Proximity of the Land with the other rail, bus, air and water modes – user perspective
d) Land Price / Real Estate Value – operator perspective
e) Commercial Development Potential / TOD Potential – Operator perspective
f) Environmental / R&R Consideration – Operator perspective

From the above parameters, there must be a balance between both the perspectives in finalisation of the ideal locations.

For the SilverLine station location, the following parameters have been considered based on the priority: -

1) Alignment: the route was decided based on the existing railway line, practicality to build new line and the topography of Kerala. The cities and towns for stations were selected based on the proximity to the macro-level tentative alignment fixed during pre-feasibility stage.
2) Catchments in terms of population: if a tier 1 city is along the alignment, then priority was given to that particular city, followed by towns under tier II and tier III.
3) Administrative headquarter – if the city or town is district headquarter, priority was given to district HQ for location of Silverline station.
4) One district one station principle – in a district, if one location has been identified as SilverLine station, no other city may be considered. But, station for airport connectivity may be considered.
5) Station-wise passenger handled and earnings – the performance of the existing railway stations along the tentative alignment based on number originating

passengers and passenger earnings is also considered. The best performing stations and respective cities or towns will be giver higher priority.

6) Secondary Data: Consideration from previous studies as follows:-
   a. Kerala High Speed Rail Corridor between Thiruvananthapuram and Kannur Detailed Project Report - June 2016 prepared by DMRC suggested ten stations proposed in the first phase which includes Thiruvananthapuram, Kollam, Chengannur, Kottayam, Kochi, Thrissur, Valanchery, Kozhikode, Kannur, and Kasaragod. One more station is planned in the next phase at Nedumbassery.
   b. Traffic & Transportation Study for preparation of DPR for Kerala High Speed Rail – 2017; updated traffic report prepared by iMacS suggested Thiruvananthapuram, Kollam, Chengannur, Kottayam, Kochi, Thrissur, Valanchery, Kozhikode, Kannur, Kasargod and Mangalore as Station locations.

Based on the above, for each major sections along the alignment, following major urban agglomerations and towns were considered.

Table 4-1: Urban Centres Considered for SilverLine Stations

Sl. No.	Sections (District to District)	Major Urban centres for probable station locations
1	Thiruvananthapuram - Kollam	Thiruvananthapuram UA, Varkala, Aatingal, Paravoor
2	Kollam - Alapuzha/Pathanamthitta	Kollam UA, Adoor, Pandalam,
3	Alapuzha/Pathanamthitta - Kottayam	Chenganoor, Tiruvalla, Changanassery
4	Kottayam - Ernakulam	Kottayam UA, Piravam, Tripunithara, Vaikom
5	Ernakulam - Trissur	Ernakulam UA, Aluva, Angamaly, Chalakudy
6	Trissur - Malapuram	Trissur UA, Kunnamkulam, Kuttipuram, Edappal
7	Malapuram - Kozhikode	Tirur, Tirurangadi, Feroke, Parappanagandi
8	Kozhikode - Kannur	Kozhikode UA, Quailandy, Vadakara, Thalassery
9	Kannur - Kasaragod	Kannur UA, Payyanur, Kanjagad UA, Kasaragod UA
10	Airport connectivity	Thiruvananthapuram, Kochi, Karippur, Kannur

Catchment and Population

The population of each city and town considered for stations are provided in the table below along with their ranking within the class or tier towns.

Table 4-2: Urban centres & Population

Sl.No.	Rank	City/Towns	Population (Census 2011)	Class (Tier)
1	1	Kochi UA	1,355,972	I
2	2	Thiruvananthapuram UA	889,635	I
3	3	Kozhikode UA	880,247	I
4	4	Kannur UA	498,207	I
5	5	Kollam UA	380,091	I
6	6	Thrissur UA	330,122	I
7	7	Alappuzha UA	282,675	I
8	9	Kottayam UA	172,878	I
9	13	Kanhangad UA	129,367	I
10	14	Vadakara UA	124,083	I
11	3	Kasaragod UA	75,968	II
12	5	Quilandy (M)	68,982	II
13	6	Payyannur (M)	68,734	II
14	10	Thiruvalla (M)	56,837	II
15	12	Tirur (M)	53,654	II
16	13	Changanassery (M)	51,967	II
17	14	Kunnamkulam (M)	51,592	II
18	2	Chalakudy (M)	48,380	III
19	8	Varkala (M)	40,728	III
20	9	Paravoor (M)	38,652	III
21	13	Attingal (M)	35,693	III
22	22	Adoor (M)	28,952	III
23	30	Chengannur (M)	25,397	III
24	31	Vaikom (M)	22,641	III

From the above table, from Thiruvananthapuram, Kollam, Kottayam, Ernakulam, Trissur, Kozhikode and Kannur, the urban agglomerations are selected for station locations. It is also observed that, they also serve as district HQs. As the alignment do not pass through Alapuzha UA, it cannot be selected. The towns from Alapuzha, Pathanamthitta, Malapuram and Kasaragod as station locations will have to finalised based on the performance of existing railway stations as there are multiple towns other than district HQs along the alignment which are probable for having stations.

Performance of Existing Railway Stations

The performance of existing railway stations in terms of passenger handled and earnings are considered in this section. The top 20 station based on the ranking based on passenger earnings from each station are provided in the table below for Thiruvananthapuram and Palakad Division.

Table 4-3: Station-wise performance – Thiruvananthapuram Division

Rank	Station Name	Station Code	No. of Actual Passenger	Annual Earnings (In Rs.)	No. of Actual Passenger (per Day)	Earnings per day (In Rs.)
1	Thiruvananthapuram Central	TVC	14604759	1918713232	40908	5270627
2	Ernakulam Jn	ERS	10282088	1656309076	28170	4537833
3	Trissur	TCR	6887232	1079227597	18869	2956788
4	Ernakulam Town	ERN	4119857	667006491	11287	1827415
5	Kollam Jn	QLN	8412506	642310800	23048	1759756
6	Aluva	AWY	4439930	621608174	12164	1703036
7	Kottayam	KTYM	4769050	579294371	13066	1587108
8	Nagarcoil Jn	NCJ	2692661	506849949	7377	1388630
9	Chengannur	CNGR	2736961	480557142	7499	1316595
10	Kayankulam Jn	KYJ	3162376	344784651	8664	944615
11	Kochuveli	KCVL	627652	243243266	1720	666420
12	Alappuzha	ALLP	2385518	215015730	6536	589084
13	Kanniyakumari	CAPE	756294	196672113	2072	538828
14	Tiruvalla	TRVL	1663781	193374981	4558	529794
15	Chenganasseri	CGY	1526575	109335208	4182	299549
16	Varkala Sivagiri	VAK	3964010	104254286	10860	285628
17	Tripunittura	TRTR	858280	80571256	2351	220743
18	Valliyur	VLY	293696	78359811	805	214684
19	Angamali for Kaladi	AFK	1833706	69626465	5024	190757
20	Cherthala	SRTL	1513948	67785629	4148	185714

Source: Southern Railway – Thiruvananthapuram Division: Annual originating passengers & earnings for the year 2017-18

From the above table, Chenganoor can be finalised as station location between Alapuzha/Pathanamthitta – Kottayam section when compared with Tiruvalla and Changanassery.

Similarly, the station-wise ranking based on performance for Palakad division is provided in table below.

Table 4-4: Station-wise performance – Palakad Division

Rank	Station Name	Code	Originating Passengers	Originating Earnings	Average Passengers per day	Average Earnings per day
1	Kozhikkode	CLT	10388999	1141636403	28463	3127771
2	Mangaluru Central	MAQ	5716180	815443543	15661	2234092
3	Kannur	CAN	7251566	717299105	19867	1965203
4	Palakkad Jn	PGT	4042031	616930828	11074	1690221
5	Shoranur Jn	SRR	4063152	478074537	11132	1309793
6	Thalassery	TLY	4442403	324970020	12171	890329
7	Mangaluru Jn	MAJN	667096	317108702	1828	868791
8	Tirur	TIR	3565350	236951671	9768	649183
9	Vadakara	BDJ	3638020	201174724	9967	551164
10	Kasargod	KGQ	2453877	195369393	6723	535259
11	Payyannur	PAY	2859033	187748867	7833	514380
12	Kanhangad	KZE	2480074	151408582	6795	414818
13	Quilandi	QLD	1797984	111806551	4926	306319
14	Ottappalam	OTP	1025690	111574412	2810	305683
15	Kuttipuram	KTU	2168702	106144079	5942	290806
16	Parapanangadi	PGI	1333136	66553812	3652	182339
17	Ferok	FK	1126176	45311798	3085	124142
18	Nilambur Road	NIL	965016	45168962	2644	123751
19	Nileshwar	NLE	1147906	41421776	3145	113484
20	Pattambi	PTB	863608	41400541	2366	113426

Source: Southern Railway – Palakad Division: Annual originating passengers & earnings for the year 2017-18

From the above table, Tirur between Malapuram and Kozhikode and Kasaragod between Kannur and Kasaragod can be finalised for station location. Kanhangad is also a major UA within the region and also performing similar to Kasaragod in terms of passenger and earnings but being the District HQ, Kasaragod can be finalised.

Regarding connectivity to airports, Kochi may be considered for connectivity as it is along the alignment and is also major international airport. Other airport connectivity may be decided based on the daily ridership.

Summary of finalised SilverLine Station locations

Based on the above assumptions and considerations, the station locations finalised for SilverLine are provided in the table below.

Table 4-5: Identified Urban centres considered for SilverLine stations

Sl. No.	Sections (District to District)	SilverLine Station Locations
1	Thiruvananthapuram - Kollam	Thiruvananthapuram UA
2	Kollam - Alapuzha/Pathanamthitta	Kollam UA
3	Alapuzha/Pathanamthitta - Kottayam	Chenganoor
4	Kottayam - Ernakulam	Kottayam UA
5	Ernakulam - Trissur	Ernakulam UA
6	Trissur - Malapuram	Trissur UA
7	Malapuram - Kozhikode	Tirur
8	Kozhikode - Kannur	Kozhikode UA
9	Kannur - Kasaragod	Kannur UA, Kasaragod UA
10	Airport connectivity	Kochi Airport

4.1.1.2 SilverLine Distance and Time

The 11 SilverLine Stations proposed along the alignment and corresponding codes with SilverLine Distance and time are shown in **Table** 4-6.

Table 4-6: SilverLine Distance - Time Chart: From Thiruvananthapuram (TVM)

Sl. No	Station Name	Station (Code)	Chainage (In Km - Distance From TVM)	Run Time (In Hrs: Min)
1	THIRUVANANTHAPURAM	TVM	0.000	0:00
2	KOLLAM	KLM	55.338	0:24
3	CHENGANNUR	CNGR	102.900	0:46
4	KOTTAYAM	KTM	136.108	1:01
5	ERNAKULAM	EKM	195.329	1:27
6	KOCHI AIRPORT	KAP	212.318	1:36
7	THRISSUR	TSR	259.117	1:57
8	TIRUR	TIR	320.562	2:24
9	KOZHIKODE	KKD	357.868	2:42

Sl. No	Station Name	Station (Code)	Chainage (In Km - Distance From TVM)	Run Time (In Hrs: Min)
10	KANNUR	KNR	446.095	3:20
11	KASARGOD	KGD	529.450	3:56

4.1.2 District & City Profile

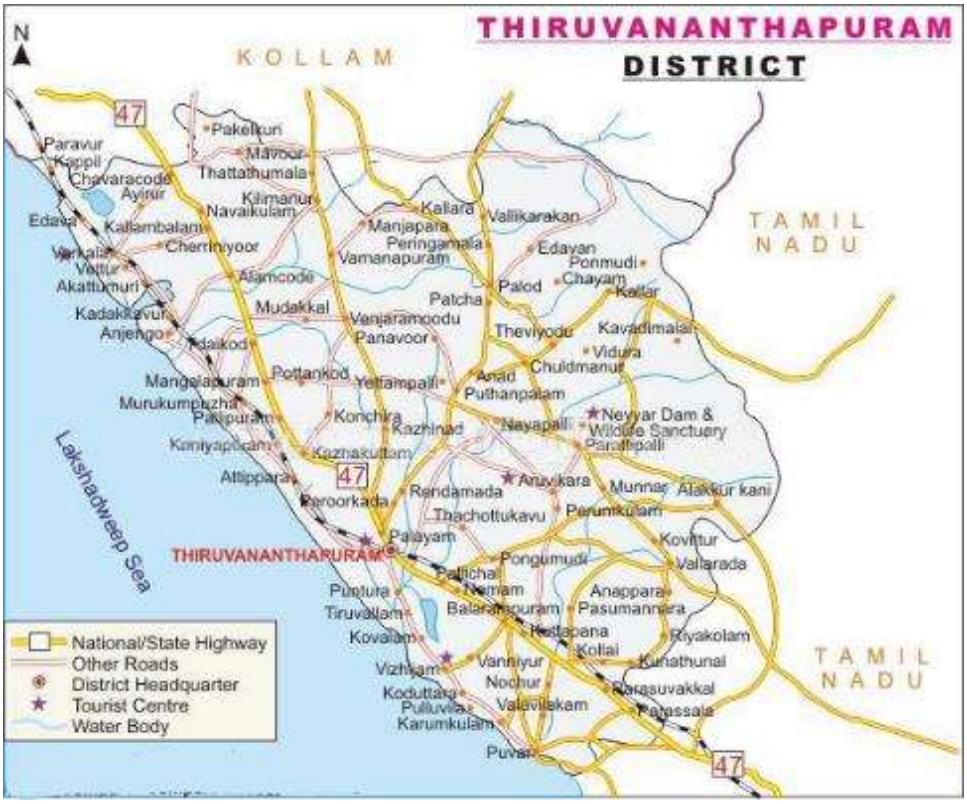
In this section, major districts and cities are detailed which are along the SliverLine alignment. The profile in terms of activity and activity centres, social (cultural), and connectivity within the district and city is provided in subsequent sub-sections.

4.1.2.1 Thiruvananthapuram

The capital city of Kerala with Government offices, educational institutions, headquarter to Kerala public sector undertakings and notably academic, IT and research hubs. The place is also known for hosting various cultural events of national & international stature and the diverse ethnic populace of the city celebrates several local festivals. Out of the local festivals, Atukal Pongala (which normally happens in early March of the year) is most famous and bring in lakhs of devotees from across Kerala to Thiruvananthapuram.

With nearly 80% of the state's software exports, Thiruvananthapuram is a major IT hub with the Techno Park and the Techno city. It is an academic and research focal point in the country. Being India's largest city in the deep south, it is strategically prominent and has the Southern Air Command headquarters of the Indian Air Force, the Thumba Equatorial Rocket Launching Station and the upcoming Vizhinjam International Deepwater Motherport.

Thiruvananthapuram is a major tourist centre, known for the Padmanabhaswamy Temple, the famous beaches of Kovalam and Varkala, the backwaters of Poovar and Anchuthengu and its Western Ghats tracts of Ponmudi and the Agastyamala. It is consistently ranked among the best cities to live in Kerala as well as India. The location map of Thiruvananthapuram is provided in the figure below.



Source: http://indiannewsreader.blogspot.com/2009/12/kerala-tourism-trivandrum.html

Figure 4-2: Thiruvananthapuram District

Regarding connectivity, the NH 66 and NH 544 (old NH 47) connects the city with Salem and Kanyakumari in Tamil Nadu. The Main Central Road is an arterial road in the city and is designated as State Highway 1.

There are five railway stations in the city namely, the Thiruvananthapuram Central, Thiruvananthapuram Pettah, Kochuveli, Kazhakuttom and Nemom. Thiruvananthapuram Central is the major railway station serving the city. It falls under the Southern Railway zone of the Indian Railways and is the head quarter of the Thiruvananthapuram Railway Division. Thiruvananthapuram is served by the Thiruvananthapuram International Airport. The airport is just 6.7 kilometres from the city centre.

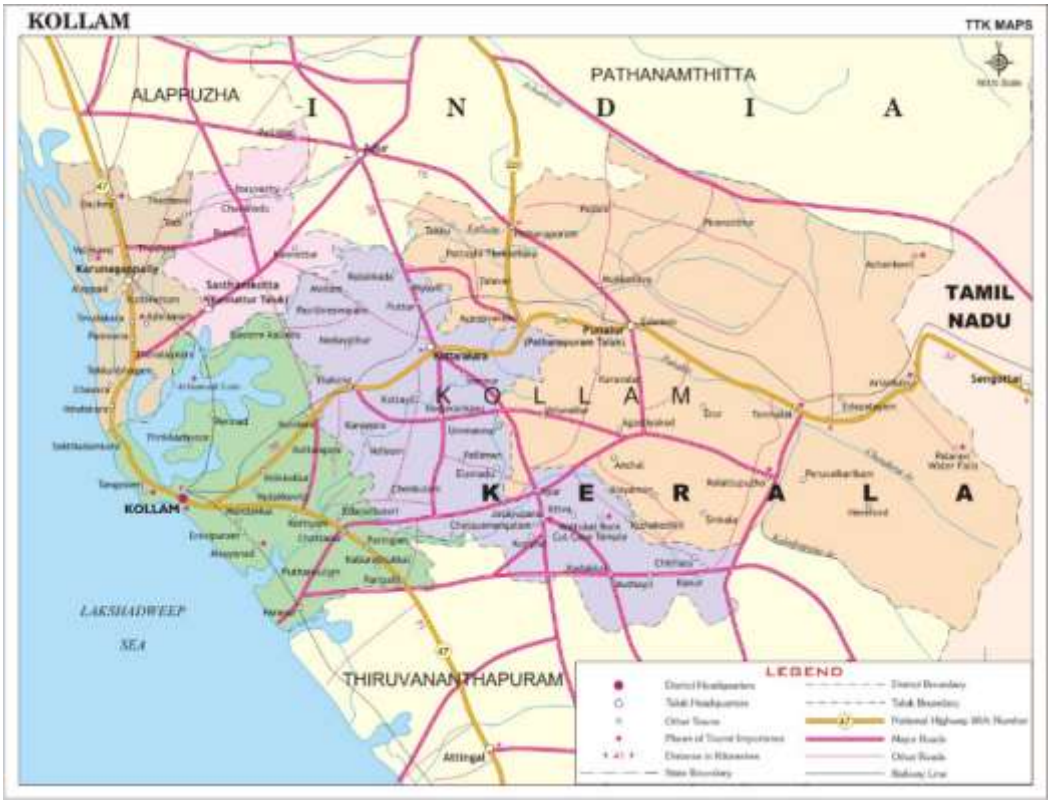
Some of the major institutional area within the city are – Secretariat, Palayam - Corporation office, Legislative Assembly and Kazhakuttam – Technopark. Major educational institutional area includes Medical College, Srikaryam, Palayam - Kerala University Campus etc.

4.1.2.2 Kollam

Kollam is the fourth largest city in Kerala and situated 66Km away from State Capital – Trivandrum and is one of the oldest settlements in Kerala. Thangassery and Neendakara ports triggered the development activities in the region and led to the growth of settlements around these ports and thus Kollam developed as an important commercial

center in the southern part of Kerala. Historically a trading town and presently a commercial and business centre. The city also have major fishing harbours both for sea and backwater fisheries sector.

The route through Punalur to Tamil Nadu is used for daily movement of goods and passengers. As per the recent publication by UN through Economic Intelligent Unit has placed Kollam as the 10th fastest growing city in the world with 31.1% urban growth. The Kollam district map is provided in the figure below.



Source: https://maps.newkerala.com/Kollam-District-Map.php

Figure 4-3: Kollam District

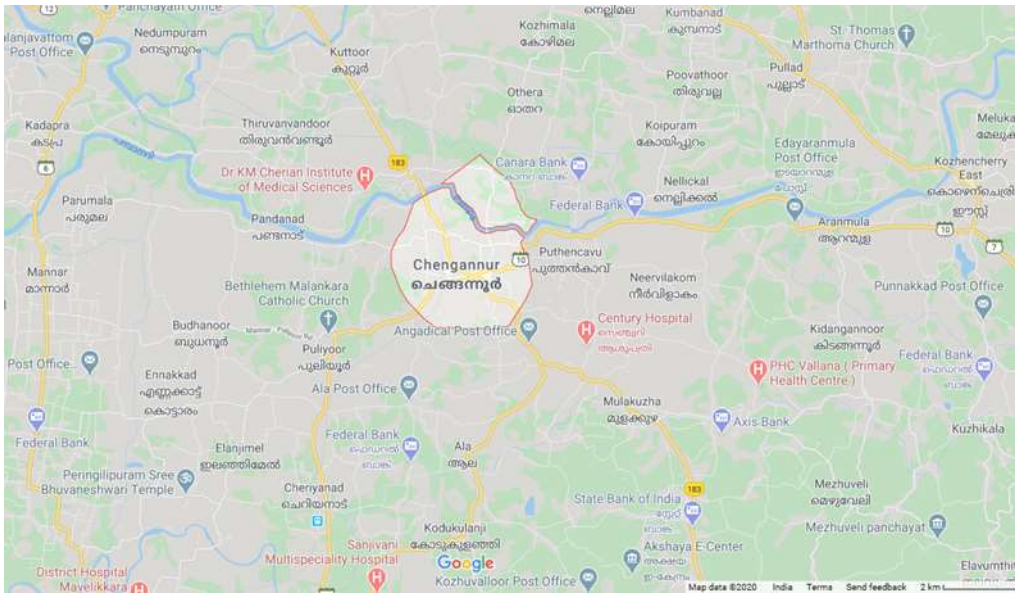
The city of Kollam is connected to almost all the cities and major towns in the state, including Trivandrum, Alappuzha, Kochi, Palakkad, Kottayam, Kottarakkara, and Punalur, and with other Indian cities through the NH 66, NH 183, NH 744 - and other state PWD Roads. Road transport is provided by state-owned Kerala State Road Transport Corporation (KSRTC) and private transport bus operators. Kollam is one among the five KSRTC zones in Kerala. Road transport is also provided by private taxis and auto rickshaws, also called autos. There is a city private bus stand at Andamukkam. There is a KSRTC bus station beside Ashtamudi Lake. Buses to various towns in Kerala and interstate services run from this station.

The city also has Kollam Junction Railway Station and all the trains have halt at this station. MEMU service to Ernakulam and services to Senkottai through Arayankavu is also a prominent rail service.

The major commercial & institutional area within the district are Kollam City Centre, Punalur, Paravur and Kottarakara. It is also famous for religious activites and the famous are Karunagapally mosque and the related festivals and Kottarakara temple. The tourism locations include island and resorts situated around the Astamudi Lake. The Munroe Island, and related backwater tourism is a major activity.

4.1.2.3 Chengannur

The town is situated on the southernmost tip of Alapuzha District and along the river Pamba. It is close to major religious places in Kerala and Sabarimala Temple is accessed from Chengannur while travelling by Rail and also by Road. Sabarimala temple is visited by approximately 3 crores of devotees a year and maximum in 3 months of duration from November to January. The major boat race such as the Aranmula Boat race happens close to Chengannur town. The famous Maramon convention is also hosted near to changanoor town. Major commercial & institutional area within the town includes – Chengannur, Adoor and Pandalam. Major tourism/religious locations within the proximity are Sabarimala, Aranmula, Pandalam, Parumala and the Maramon, where Maramon convention takes place. The location of chengannor town is provided in the figure below:-



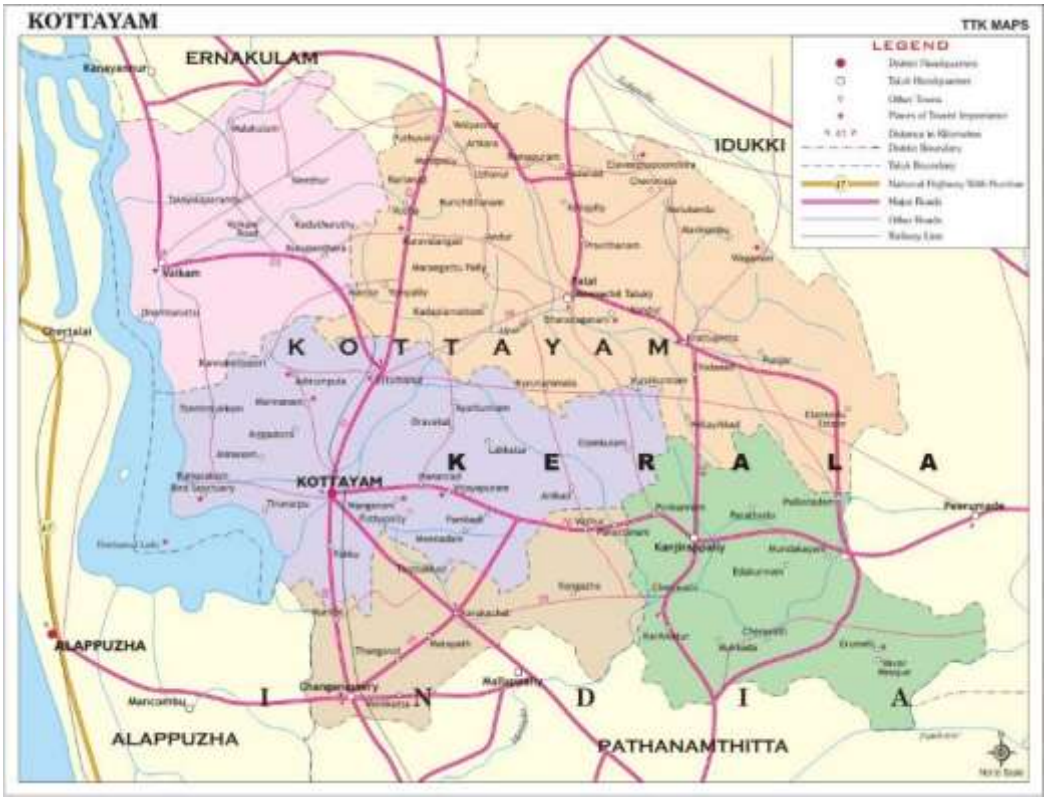
Source: https://www.google.com/maps/place/Chengannur

Figure 4-4: Chengannur Town

Chengannur is well connected to cities and towns in the north and south of Kerala through State Highway (SH 1 – Main Central Road or MC Road). NH 183A and SH 67 in the east-west direction connects the town with Sabarimala. The town also have a railway station with all the major express trains having stop at the station.

4.1.2.4 Kottayam

The city is located at the centre of the state and is one of the flag bearers of literacy mission in Kerala. It is the first district with 100% literacy in India. The city is an important trading center of spices and commercial crops, especially rubber. A number of small and medium-sized enterprises in and around the town are engaged in the processing of rubber latex and manufacturing of rubber products. The location map of Kottayam district is provided in the figure below.



Source: https://maps.newkerala.com/Kottayam-District-Map.php

Figure 4-5: Kottayam District

Many religious & tourist destinations are in the proximity of Kottayam town such as Kumarakom, Wagamon, Ettumanoor, Vaikom, Erumeli and other main tourist destinations along western ghats. The major commercial and institutional area in the district is the Kottayam town itself.

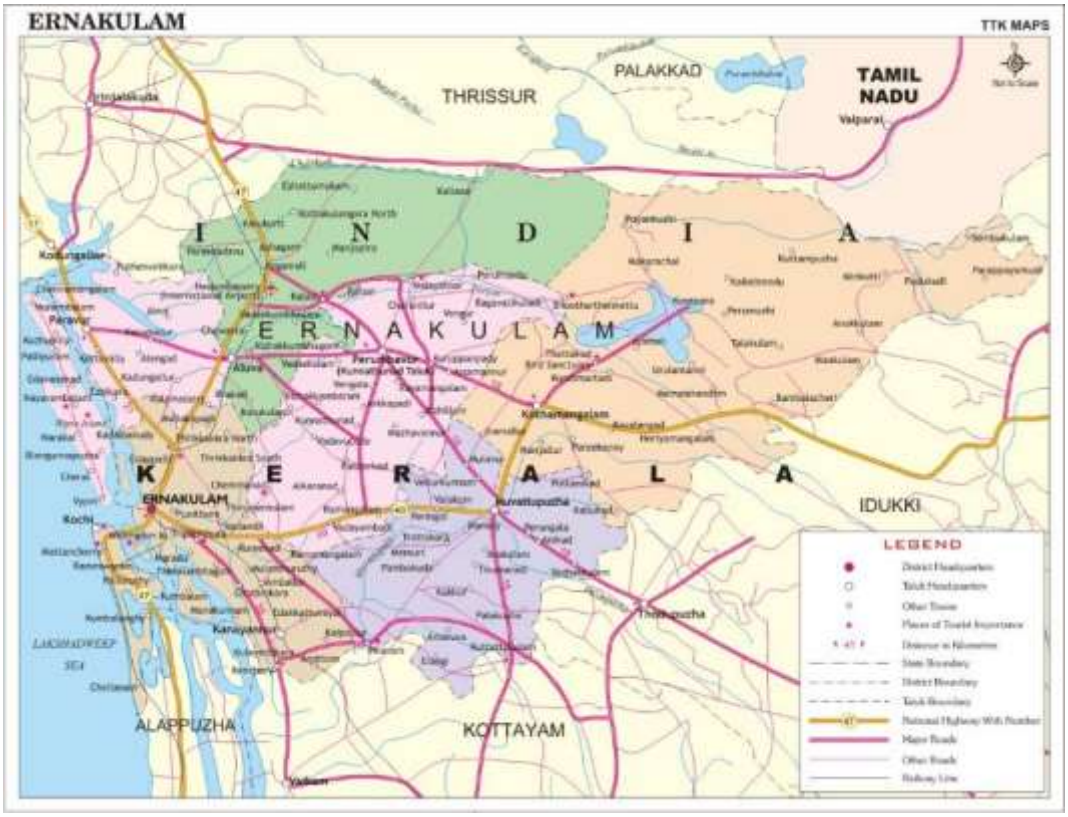
Kottayam is connected to Ernakulam by SH 15, to Chertala by SH 40, and by NH 183, which connects to Dindigul. The SH 1 (MC Road) connects Kottayam to Thiruvananthapuram in the South and Angamali in the North of Kerala.

The major railway station is the Kottayam railway station and is well connected to other parts of Kerala and India.

4.1.2.5 Ernakulam

Kochi is a major port city on the west coast of Indian Peninsula and also one of the most densely populated cities in the state of Kerala. In the past decade, Kochi has witnessed increased economic growth with improved investments in projects such as Vallarpadom International Container Terminal (VICT), port based Special Economic Zone, and Industrial parks like Smart City, Info City etc. All these strategic investments have given a boost to the regional economy and employment. Several other projects are also proposed in Kochi city and region, some of them being of national importance, with an anticipation of further encouraging the economy. As per the Census of India 2011, the city (Kochi Municipal Corporation) has a population of about 6.4 lakh, spread over an area of 94.86 Sq. km.

The City of Kochi is the nerve center of trade and commerce of Kerala and is considered as the 'Gateway of South India'. Kochi with its wealth of historical associations and its unique setting perfectly reflects the historical blend of Kerala. Kochi is one of India's important ports and a major naval base. Kochi consists of mainland Ernakulam, the Islands of Willington, Bolghatty and Gundu in the Harbour, Fort Kochi and Mattancherry on the southern peninsula and Vypin Island, north of Fort Kochi. Kochi Municipal Corporation was formed in 1967, incorporating three municipalities (Fort Kochi, Mattancherry and Ernakulam), Willington Islands and few surrounding areas in the suburbs. Greater Cochin Development Authority (GCDA) and Goshree Islands Development Authority (GIDA) have delineated the development area which is considered as Greater Cochin Region comprising Kochi Municipal Corporation, 9 Municipalities and 29 Panchayats. The total area under Greater Cochin Region is 632 sq.km with a population of 20.01 lakhs (as per Census 2011). The location map of Ernakulam District is provided in the figure below.



Source: http://tourismindia03.blogspot.com/2011/01/ernakulam-town-ernakulam-map-ernakulam.html

Figure 4-6: Ernakulam District

Three major national highways connect Kochi with other parts of the country. NH 66 (old NH 17) from Kochi to Mangalore, connects Kochi with Mumbai via most of the major towns in the Malabar area, the west Karnataka port town of Mangalore and the State of Goa. The NH 544 (old NH 47) from Kanyakumari to Salem connects Thiruvananthapuram with Kochi and continues to connect to Coimbatore and Salem in Tamil Nadu via Palakkad and Thrissur. NH 49 connects Kochi with Rameswaram in Tamil Nadu and passes through Madurai via the hill resort of Munnar. Kochi is well connected to other parts of state through various state highways.

It also has an MRTS network connecting Aluva to Thykudam (to Petta under construction) connecting two major railway stations and major bus terminals – Vytilla Mobility hub, Aluva municipal bus stand etc.

Kochi is well connected to major urban centres in the state as well as to other places through major railway lines namely Thiruvananthapuram – Palakkad railway line via Kottayam and Thiruvananthapuram – Kozhikode. Ernakulam Town and Ernakulam junction are the main Railways stations in the region. Kochi has a good network of inland waterway system consisting of backwaters, canals and lagoons. National waterway No. 3 connecting Kollam and Kottappuram pass through the region.

Cochin International Airport at Nedumbassery (near Angamali town), 28 km from the city, is the largest airport in Kerala in terms of passengers and number of flights. The airport is well connected by many international & national carriers that operate regular flights to the Middle East and elsewhere in Asia. Many direct chartered services from Europe and the US reach Kochi during tourist seasons. Domestically the airport is well connected to the other main cities in India.

It is also well-connected to the sea port and the airport is approximately 25 km from the junction. The National Waterway 3 is also located very near to the site, and it is connected to Kollam and Kottapuram.

The major commercial & institutional towns within the region are Ernakulam (CBD), Kakkanadu, Aluva, Angamali, Fort Kochi, Paravur, Trikakara and Tripunithara. There are many famous churches, temples and mosques in the region which attract lakhs of devotees during the annual festivals. The Kochi-Muziris Biennale, hosted by the city during the month of December, January and February is also becoming a major cultural event in the city attracting, domestic and international tourist just visiting the city for the event.

4.1.2.6 Thrissur

Thrissur is known as the cultural capital of Kerala and is also a commercial and financial hub. The city is the largest in manufacturing plain gold and other gold jewellery in Kerala with major and minor units. It is also headquarter to most of the commercial banks in Kerala. The main activity centre is the Trissur town and is famous for the Trissur Pooram. The festival attracts lakhs of devotees in three days of a year. The district is also famous for other church, mosque and temple festivals. Some of the well-known temples and churches are Vadakkumnathan temple, Guruvayur temple, the Our Lady of Lourdes Syro-Malabar Catholic Metropolitan Cathedral and the Our Lady of Dolours Syro-Malabar Catholic Basilica, the largest Christian church in India. India’s first mosque, the Cheraman Juma Masjid is also situated in the district. The famous Kerala Kalamandalam, a hub of art and culture is also situated in the district along the banks of Barathapuzha river. The location map of Trissur is provided in the figure below.

Source: https://maps.newkerala.com/Thrissur-District-Map.jpg

Figure 4-7: Thrissur District

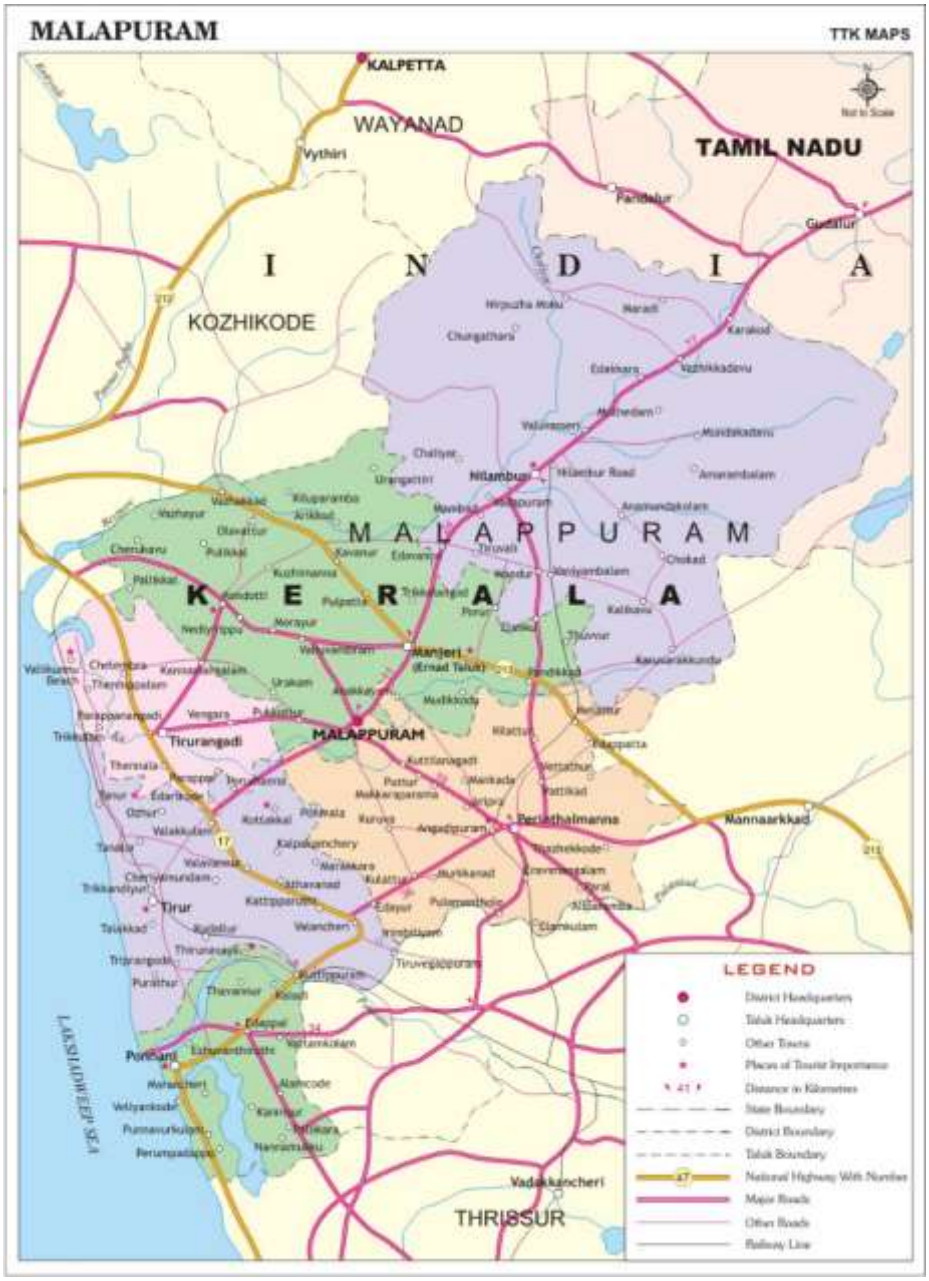
The NH 544 (old NH 47) is the main highway that connects the city and district with other parts of Kerala and South India. The SH 69: Thrissur-Kuttippuram Road, SH 22: Kodungallur – Shornur Road, SH 75: Thrissur – Kanjani – Vadanappally Road are the three state highways which connect city with nearby towns.

The Trissur railways station is a major station with halt to all the major trains operating in Kerala.

4.1.2.7 Malappuram & Tirur

As per census 2011, Malappuram is the most populous district in Kerala (approximately 13%). As per the recent publication by UN through Economic Intelligent Unit has placed Malappuram as the fastest growing city in the world with 44% urban growth from 2015 to 2020. As per State planning board, Malappuram is also the district with maximum emigrants in the state. The district also has highest number of schools in Kerala. The district is home to most of the notable poets and artists in Kerala. The Mappila dance forms like Oppana, Kolkali, Duffmuttu, and Aravana muttu are popular in the district. One of the main centre for Ayurveda in Kerala is situated in the district near Kottakal.

Most of the commercial activities are centered around Manjeri in the District. Other major towns and activity centres are Ponnani, Perinthalmanna, Tirur, Eranad, Tirurangadi, Kondotty, and Nilambur. The location map of the Malappuram district is provided in the figure below.



Source: https://maps.newkerala.com/Malappuram-District-Map.php

Figure 4-8: Malappuram District

Tirur: It is one of the business centres of Malapuram District and is a stoppage point for access to other religious centres in the proximity. The main items of trade includes mobile gadgets, electronic items and betel leaf.

The major commercial & institutional area in Tirur is the Tirur Town and the major religious temple of Tirunavaya is situated in the proximity.

The district is connected through NH 66 and NH 966 to other major cities and towns in the North and South of Kerala. The major towns and cities within the district are connected through SHs - SH 23, SH 60, SH 69, SH 70 etc.

The major railways stations are Kuttipuram, Angadipuram, Tirur and Nilambur (which connects to Shornur as separate line).

4.1.2.8 Kozhikode

Kozhikode, also known as Calicut, is a city in the state of Kerala in southern India on the Malabar Coast. Kozhikode is the largest urban area in the state and 195th largest urban area in the world. As per the recent publication by UN through Economic Intelligent Unit has placed Kozhikode as the 4th fastest growing city in the world with 34.5% urban growth from 2015 to 2020. The greater Calicut urban area in the Malabar Coast is the part of the ninth biggest urban area in the world and the second biggest in India after the greater Kolkata urban area, which constitute of the northern Kerala region or the Malabar Coast.

In terms of urban agglomeration (UA), it is the second largest UA in Kerala and also an commercial hub in the state. A culturally rich region which is different from other regions and has produced many famous celebrities from the field of dance, move, classical instruments etc. Major premier institutes such as NIT and IIM is located in the region. An international airport is also operational from the region. IT park in line with Technopark and Infopark, which is known as Cyberpark is also under development stage.

The major commercial & institutional establishments are centred around Kozhikode city and the major tourist locations are Kozhikode beach, Kappad and Kuttiyadi.

The location map of Kozhikode is provided in the figure below.

Source: https://keralainformations.wordpress.com/kozhikode-india-kerala/

Figure 4-9: Kozhikode District

NH 66 connects Kozhikode to Mumbai via Mangaluru, Udupi and Goa to the north and Kochi and Kanyakumari near Thiruvananthapuram to the south. NH 766 connects Kozhikode to Bangalore through Kollegal in Karnataka and NH 966 connects Kozhikode to Palakkad through Malappuram. The major SHs are SH 29, SH 34 and SH 54 that connects other major towns within the region.

The major railway station is the Kozhikode and all the trains passing through the station has a halt for passenger movement.

For intra-city travel, LRT is under consideration and technical studies are conducted by KRTL (Kerala Rapid Transit Corporation Limited) and the proposed alignment connects all the major transport hubs and commercial in the city.

The International Airport at Karipur serves the city with international connectivity especially with the countries in Middle-east.

4.1.2.9 Kannur

It is the 6th most urbanised district in Kerala and historically a trading town. Most of the commercial and institutional activities are centred around Kannur town. Other than diversive culture such as theyyams, it is also a politically active district. The Ezhimala Naval Academy is situated in the region. The region is also an educational hub due to the presence of institutions like NIFT, Indian Cast Guard Academy, Kannur University, Government Engineering college and Brennan College. The location map of Kannur district is provided in figure below.

Source: https://maps.newkerala.com/Kannur-District-Map.php

Figure 4-10: Kannur District

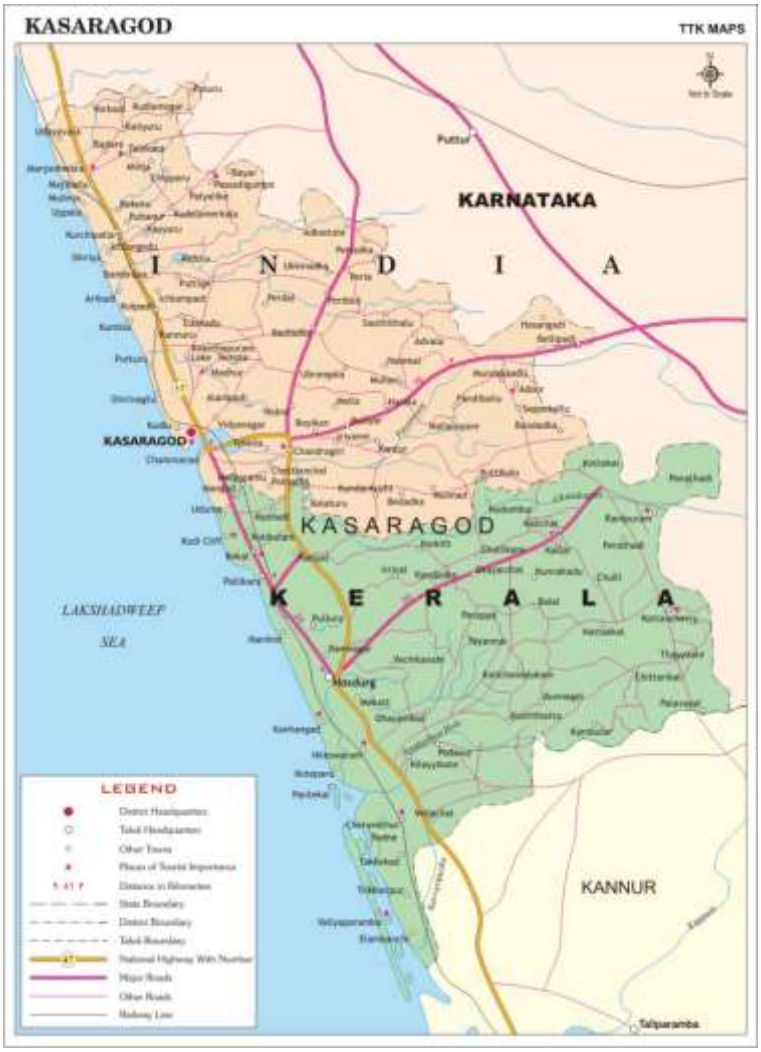
The major commercial & institutional are in Kannur Town and in Thallassery. The major tourist destination in the region is Muzappilangadu beach.

Kannur is connected via NH 66 to Mumbai via Mangaluru, and Goa to the north and Kochi and Kanyakumari near Thiruvananthapuram to the south. The major railway station is Kannur railway station.

Kannur is also connected via Air through the international Airport located at Mattanur.

4.1.2.10 Kasaragod

It is the northernmost district of Kerala and an important border district that have linkages with neighbouring State – Karnataka, especially Manguluru. Kasaragod is renowned for its hills, forts and water bodies. The famous Bekal fort in Kasaragod is the most visited place by tourists in the district. The coir and handloom industry here also famous. The major towns and activity centres are Kasaragod town and Kanhangad town. The location map of district is provided in the figure below.



Source: https://destinationkasaragod.wordpress.com/tag/kasaragod/

Figure 4-11: Kasaragod District

Kasaragod is connected via NH 66 to Mumbai via Mangaluru, and Goa to the north and Kochi and Kanyakumari near Thiruvananthapuram to the south. SHs such as SH 55 and SH31 connects to Kerala-Karnataka state border. The major railway station is Kasaragod railway station.

4.1.3 Demographic Profile

As per Census 2011, the population of Kerala State was recorded as 33.41 million persons with a decadal growth rate of 4.81%, which is lowest amongst the States of India. The district-wise population in Kerala is presented in **Table** 4-7. Malappuram District has the highest population of about 44.4 lakhs in the year 2017, followed by Kerala's capital city, Thiruvananthapuram with 33.47 lakhs; while the lowest population is observed in Wayanad district with a population of about 8.4 lakhs. As per Census 2011, the density of population of Kerala is 860 persons / sq. km as compared to 382 persons/ sq. km at an all India level.

Table 4-7: Population of Kerala

District	1991	2001	2011	2017*
Kasaragod	1071508	1204078	1307375	1379091
Kannur	2251727	2408956	2523003	2602238
Wayanad	672128	780619	817420	842536
Kozhikode	2619941	2879131	3086293	3226115
Malappuram	3096330	3625471	4112920	4439921
Palakkad	2382235	2617482	2809934	2931854
Thrissur	2737311	2974232	3121200	3225843
Ernakulam	2817236	3105798	3282388	3407138
Idukki	1078066	1129221	1108974	1094573
Kottayam	1828271	1953646	1974551	1982082
Alappuzha	2001217	2109160	2127789	2143334
Pathanamthitta	1188332	1234016	1197412	1175608
Kollam	2407566	2585208	2635375	2655423
Thiruvananthapuram	2946650	3234356	3301427	3347613
Total	29098518	31841374	33406061	34453369

** Source: Vital Statistics Division, DES, Kerala & Census of India*

The decline in growth rate may act as detrimental factors to patronage. But, more employment generation, especially in the field of IT sector may increase in-migration. The IT companies are shifting their base to next tier cities from metro cities of India and many cities in Kerala are in the potential list. Kerala is also witnessing an in-migration in the primary sector due to shortage of labour.

4.1.4 Socio-Economic Profile

Kerala has the highest quality of life index in the country, a high literacy rate at 94% against country's literacy rate of 74% and has a good socio – economic status compared to other Indian States. Kerala's health indicators and life expectancy are close to those of developed countries. Achievements in health and education fronts were to a large extent possible through infrastructure investments. It also has had an edge over many other States in social and economic infrastructure, such as road transport, medical institutions and healthcare facilities.

Kerala is a Consumer State and the economy mainly depends on agriculture, fisheries, tourism, service sector and with a very few industries. Tourism has grown to be the fund generating industry. As per the Kerala State Planning Board, *'The upcoming of IT and allied industries coupled with small and agro-based has a lot to look forward in future in terms of economy of Kerala which are willing to exploit the yet-to-be tapped resources. The State has witnessed significant migration, especially to the Gulf Cooperation Council (GCC) Countries region during the Kerala Gulf boom and is thus heavily dependent on the remittances from the large expatriate community, which contributes more than a fifth of GSDP. Certain Socio-Economic aspects of the State are discussed below'*.

4.1.4.1 Economy

As per the Kerala Economic Review 2018, '*Kerala's Gross State Domestic Product*[2] *(GSDP) grew at 7.18% in 2017-18 at constant (2011-12) prices, which is higher than the 6.22% growth recorded in 2016-17. At current prices (@2011-12 prices), the growth rates of GSDP in 2017-18 and 2016-17 were 11.42% and 9.67% respectively. The growth rates of Gross State Value Added*[3] *(GSVA) at basic prices in constant (2011-12) prices were 5.94% and 4.67% in 2017-18 and 2016-17 respectively. The GSVA growth rate in current prices was 10.37% in 2017-18 and 8.62% in 2016-17. Per capita GSDP in real terms grew at 6.65% in 2017-18 as against 5.70% in 2016-17.*

In 2017-18, the contribution from primary, secondary, and tertiary sectors to the GSVA at constant prices (2011-12) was 10.85%, 27.40% and 61.75% respectively. At current prices, the primary, secondary, and tertiary sectors contributed 13.20%, 24.24% and 62.56% respectively to the GSVA during this period'.

Table 4-8 presents the GSDP of Kerala from year 2011-12 to year 2017-18.

Table 4-8: GSDP of Kerala

Gross State Domestic Product of Kerala							
Item	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**	**2016-17(P)**	**2017-18(Q)**
GSDP at Current Prices (Rs. In Lakhs)	36404788	41231300	46504121	51256405	56199361	61635704	68676443

[2] GSDP: Gross State Domestic Product (GSDP) is defined as a measure, in monetary terms, of the volume of all goods and services produced within the boundaries of the State during a given period of time, accounted without duplication. – reference: https://data.gov.in/keywords/gsdp.

[3] GSVA: Gross value added (GVA) is an economic productivity metric that measures the contribution of a corporate subsidiary, company or municipality to an economy, producer, sector or region. – reference: https://www.investopedia.com/terms/g/gross-value-added.asp

Gross State Domestic Product of Kerala							
Item	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**	**2016-17(P)**	**2017-18(Q)**
GSDP at Constant (2011-12) Prices (Rs. In Lakhs)	36404789	38769346	40278133	41995555	45121002	47928990	51369589
NSDP at Current Prices (Rs. In Lakhs)	32802112	37138412	41726497	46061432	50590997	55595370	61923259
NSDP[4] at Constant (2011-12) Prices (Rs. In Lakhs)	32802112	34861581	36470677	38213426	41115015	43839422	46988233
Per Capita GSDP at Current Prices (Rs.)	108666	122471	137515	150824	164554	179580	199101
Per Capita GSDP at Current Prices (Growth rate in %)		12.70%	12.28%	9.68%	9.10%	9.13%	10.87%
Per Capita GSDP at Constant (2011-12) Prices (Rs.)	108666	115158	119105	123573	132116	139645	148927
Per Capita GSDP at Constant (2011-12) Prices (Growth rate in %)		5.97%	3.43%	3.75%	6.91%	5.70%	6.65%
Per Capita NSDP at Current Prices (Rs.)	97912	110314	123388	135537	148133	161981	179523
Per Capita NSDP at Current Prices (Growth rate in %).		12.67%	11.85%	9.85%	9.29%	9.35%	10.83%
Per Capita NSDP at Constant (2011-12) Prices (Rs.)	97912	103551	107846	112444	120387	127729	136225
Per Capita NSDP at Constant (2011-12) Prices (Growth rate in %)		5.76%	4.15%	4.26%	7.06%	6.10%	6.65%

Source: Department of Economics and Statistics Kerala, 2017

[4] NSDP: Net State Domestic Product (NSDP) is defined as a measure, in monetary terms, of the volume of all goods and services produced within the boundaries of the State during a given period of time after deducting the wear and tear or depreciation, accounted without duplication. – reference: https://data.gov.in/keywords/nsdp

Kerala has been ahead of other Indian States in achieving demographic and human development indicators. In achievement of Sustainable Development Goals (SDGs 2018) by the States in India as computed by the NITI Aayog, Kerala ranks first along with Himachal Pradesh, with a score of 69 against national average of 57. Kerala ranks first in SDGs relating to health, education, and gender equality. Public investment in educational infrastructure and quality is a priority and as a consequence the enrolment of students in Government and Government aided schools has increased.

Table 4-9 presents the GSDP of all States of India for year 2016-17(Q). **Figure** 4-12 shows the comparison of percentage growth rate of Kerala & India (by economic activity) at constant prices. **Figure** 4-13 presents the per capita income of Kerala and India.

Table 4-9: GSDP of All States

Sl No.	State/UT	2016-17(Q)				
		GSDP (Rs Crs)		Per Capita Income (Rs.)		Growth Rate of GSDP at (2011-12) Prices (%) (%)
		At Current Prices	At Constant (2011-12) Prices	At Current Prices	At Constant (2011-12) Prices	
1	Goa	62661	51847	375554	308827	12.50
2	Delhi	616826	514871	300793	249555	8.60
3	Chandigarh	31823	26631	237599	207000	6.30
4	Sikkim	20020	15339	27552	206178	6.70
5	Haryana	547396	434608	180174	143211	8.70
6	Puducherry	27739	21629	174743	137088	7.80
7	Uttarakhand	195606	162451	161102	133246	6.90
8	Maharashtra	2257032	1826296	165491	133141	10.00
9	Gujarat	1162287	984453	156527	131853	10.10
10	Kerala	621700	481839	163475	128550	7.40
11	Telangana	659074	511482	159856	122684	10.10
12	Karnataka	1132393	874395	157436	120496	7.50
13	Himachal Pr.	126020	109564	150285	119386	6.40
14	Tamil Nadu	1270490	1009145	150036	117806	4.30
15	A & N islands	6649	5566	136824	113796	9.30
23	Nagaland	21488	15511	90168	63568	5.80
24	West Bengal	879167	657883	83126	61245	7.90
25	J & K	126847	102206	78163	59924	5.40
26	Meghalaya	27228	22051	73291	58826	6.80
27	Madhya Pr.	647304	469393	74590	53047	12.30
28	Assam	254341	200790	67303	52416	5.10
29	Jharkhand	235560	194475	59799	49174	11.20
30	Manipur	21066	16989	58501	46756	3.40
31	Uttar Pradesh	1250213	974120	51014	38934	7.30

Sl No.	State/UT	2016-17(Q)				
		GSDP (Rs Crs)		Per Capita Income (Rs.)		Growth Rate of GSDP at (2011-12) Prices (%) (%)
		At Current Prices	At Constant (2011-12) Prices	At Current Prices	At Constant (2011-12) Prices	
32	Bihar	487628	361504	34409	28485	11.30
	All India	15253714	12196006	103870	82229	7.10

Source: Department of Economics and Statistics, Government of Kerala, 2017

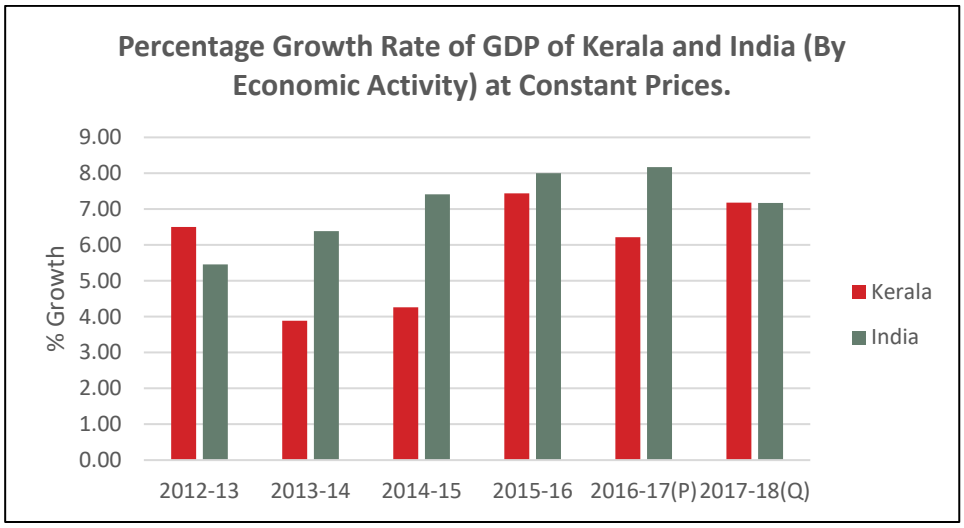


Figure 4-12 Percentage Growth Rate of Kerala & India

Source: Department of Economics and Statistics, Government of Kerala, 2017

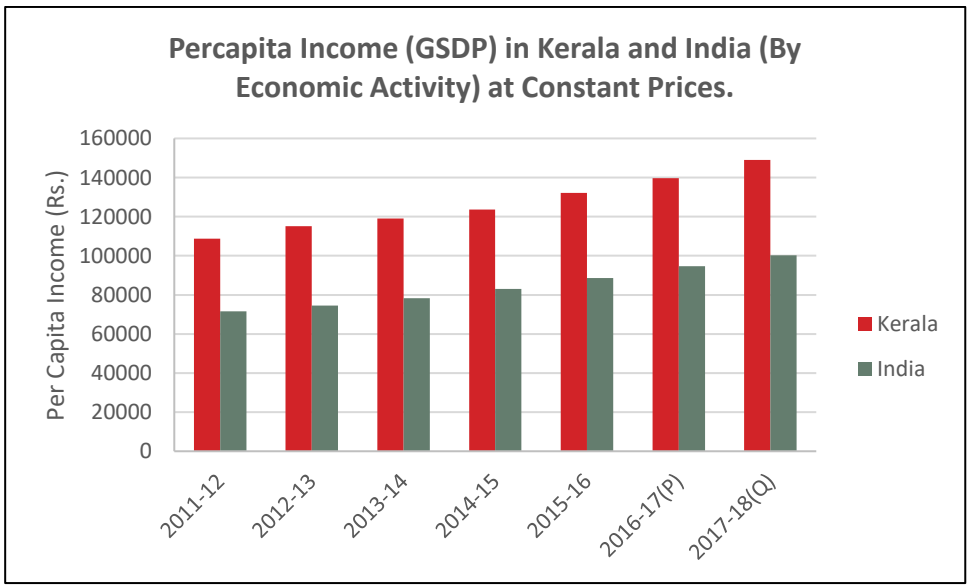


Figure 4-13 Per Capita Income in Kerala & India

Source: Department of Economics and Statistics, Government of Kerala, 2017

4.1.4.2 Sector-wise distribution of GSDP

The sector-wise annual growth rate of GSDP at constant prices is provided in the table below. For details of the Sectorial Distribution of Gross State Value Added (GSVA), please refer to Volume III, Part 3A – Annexure V.

Table 4-10: Sector Wise Annual Growth Rate of GSDP - Kerala

Base Year 2011-12		Percentage Change over Previous Year At Constant Prices		
Sl.	**Industry of Origin/Year**	**2016-17**	**2017-18 (P)**	**2018-19 (Q)**
1.	Agriculture, forestry and fishing	-0.6	1.7	-0.5
1.1	Crops	1.8	0.4	-2.1
1.2	Livestock	-7.6	1.8	-0.3
1.3	Forestry and logging	5	-0.2	0
1.4	Fishing and aquaculture	1.8	11.1	6.6
2	Mining and quarrying	45.4	18.9	-14.6
	Primary	1.2	2.7	-1.4
3	Manufacturing	18.2	3.7	11.2
4	Electricity, gas, water supply & other utility services	-13.2	27.2	12
5	Construction	7.8	4	6.3
	Secondary	11.5	4.6	8.8
6	Trade, repair, hotels and restaurants	1.7	13.3	7
6.1	Trade & repair services	1.2	13.9	7.2
6.2	Hotels & restaurants	6.6	6.6	5.1
7	Transport, storage, communication & services related to broadcasting	4.2	-2.3	-1
7.1	Railways	5	20.1	20.1
7.2	Road transport	3.2	-4.5	-3.9
7.3	Water transport	37.6	7.1	16.6
7.4	Air transport	3.1	-0.9	-3.9
7.5	Services incidental to transport	57.8	16.5	18.8
7.6	Storage	52	11.6	17.8
7.7	Communication & services related to broadcasting	1.7	-2.5	-0.8
8	Financial services	4.6	0.8	0.8
9	Real estate, ownership of dwelling & professional services	7.9	10.6	8.7
10	Public administration	9	11.2	14.7
11	Other services	12.6	9.5	17
	Tertiary	6.3	8.6	8.4
12	TOTAL GSVA at basic prices	*7.1*	*6.8*	*7.5*
13	Taxes on Products	7.5	11.8	6.4
14	Subsidies on products	-23.3	19.6	-0.3
15	Gross State Domestic Product	7.6	7.3	7.5
16	Population ('00)*	0.5	0.5	0.5

Base Year 2011-12		Percentage Change over Previous Year At Constant Prices		
Sl.	Industry of Origin/Year	2016-17	2017-18 (P)	2018-19 (Q)
17	Per Capita GSDP (₹)	7	6.7	6.9

P- provisional, Q- Quick Estimate

Source: Economic Review 2019,Volume II, Kerala State Planning Board.

From the above table, it is understood that in Primary sector, mining and quarrying was contributing higher and has decreased by -14.5 % due to banning of the activity due to recent floods. The only sector with a positive growth rate is fishing and aquaculture. It is observed that the growth rate of primary sector in terms of GSDP has decreased in the last two years. In secondary sector, manufacturing and utility segments has shown a significantly higher growth rate. The construction sector also indicated a positive growth rate. Overall, the secondary sector has faired well compared to other sectors.

In tertiary sector, all transport related segments such as railways, water transport, services incidental to transport, public administration, etc., are contributing higher. But, road transport is indicating a negative growth rate. This can also be attributed to floods and the losses it added to the road sector. The contribution from railways sector is commendable as it has shown a steady and higher growth rates and also indicates that taking up of SilverLine project from its initial stage itself will contribute well for the GSDP of Kerala.

4.1.4.3 Employment in the Organized & Unorganised Sector

Employment in organized sector: As per the Economic Review 2018, '*In Kerala, employment in the organized sector has remained more or less stagnant, showing only a marginal increase from 10.89 lakh in 2012 to 12.14 lakh in 2018. The reason behind this trend is due to the movement of the labor force to the public sector which provides more employment in the State.*

The organized sector comprises private and public sectors and it is noteworthy that private sector employment is steadily increasing since 2011 onwards. In 2018, out of 12.14 lakh persons employed in the organized sector, 5.54 lakh (46%) are in the public sector and 6.60 lakh (54%) are in the private sector. Within the public sector employment 46% are employed in State Government, 11% in Central Government, 24% are in State quasi-institutions, 4% in LSGIs and 15% are in Central quasi-institutions.

In private sector, the employment is distributed between 21 sectors and citizens are mostly employed in manufacturing sector which 26.6%, followed by education (22.5%), administrative and support (9.8%), agriculture/forestry/fishing (8.3%), Information and communication (7.9%) etc.

Data on District-wise employment as on March 2018 reveals that Ernakulam and Wayanad are the two Districts which respectively accounted for the highest and lowest employment. Total organized sector employment in Ernakulum District is 2.47 lakh persons, which accounted for 20% of the total employment of the State. Whereas in Wayanad, the employment under the organized sector is 0.35 lakh persons, which accounted for 3% of the total employment. In Kerala, men outnumbered women in public sector employment and women outnumbered men in private sector employment. The share of men is 66% of public sector employment while that of women is 51% of total private sector employment. Thiruvananthapuram and Idukki are the two Districts which respectively accounted for the highest and lowest women participation in public sector employment. In Thiruvananthapuram, 31,037 women are employed in the public sector followed by Ernakulam (22,849), Thrissur (21,891) and Kollam (18,783). Whereas in Idukki, 3,387 women are employed in the public sector followed by Kasaragod (6,502), Wayanad (6,814), and Pathanamthitta (8,266)'.

Employment in unorganized Sector: As per economic review 2019, '*More than 90 per cent of workforce and nearly 50 per cent of the Gross Domestic Product is attributable to this sector. A high proportion of socially and economically weaker sections of society are engaged in the unorganised economic activities in India and Kerala. As per the PLFS 2017-18 report published by GoI, based on usual status (ps+ss) approach, it is estimated that self-employed workers in Kerala constituted 40.7 per cent of the total workers, while the share of regular wage/ salaried employee was 24.7 per cent'.* As per census 2011, the main worker population in Kerala constitute to 93,29,747 workers.

4.1.4.4 Remittances - Contribution to Kerala Economy

As per the world bank, the top remittance recipients were India with $79 billion, followed by China ($67 billion), Mexico ($36 billion), the Philippines ($34 billion), and Egypt ($29 billion). In 2019, remittance flows to low- and middle-income countries were predicted to reach $550 billion, to become their largest source of external financing. In India, Kerala State accounts for the highest remittance with 19%.

The Centre for development studies (CDS), Kerala; conducted Kerala Migration Survey and the results were published through the working paper – 483, Emigration and Remittances: New Evidences from the Kerala Migration Survey (KMS), 2018. The working paper was published in 2019 and the major outcomes of the survey are as follows:-

a) There are 2.1 million emigrants from Kerala across the world, and among the 14 districts, four (Malappuram, Kannur, Thrissur, and Kollam) account for 50% of the emigrants.

b) The estimated total remittances to Kerala are Rs 85,000 crore as per KMS 2018. Within Kerala, one-fifth of the total remittance is to Malappuram (21%), followed by Kollam (15%) and Thrissur (11%).
c) Remittances as percent of NSDP was 25.5% in 1998, 30.7% in 2008 and increased to 36.3 in 2014 and suddenly declined to 19.3% in 2018.
d) Emigration figures showed a constant increase during the period 1998-2013 (34.9%) but declined thereafter till 2018 and indicated negative growth of 11.6% compared to 2013. The main reasons for the decline are as follows:-
    (1) Demographic advances have decreased the population in the migration-prone age group (15-29 years) since Kerala attained replacement-level fertility as early as 1987.
    (2) Wage levels in the Gulf economies have not improved after the global financial crisis.
    (3) Wages in the domestic economy have increased compared to other states; Kerala has the highest wage rate in the informal sector in India.
    (4) Prices of oil have been declining since 2010 and construction and other services are not as vibrant as it used to be.
    (5) Due to Nationalisation policies such as Nitaqat and recently introduced family taxes in Saudi Arabia, the Gulf economies are not conducive for current and prospective migrants.
    (6) Decades of investment in education have made Keralites skilled. High-skilled labour migrates to other parts of the world, mainly to the developed economies in the West.
e) The emigrants are now concentrating more on investing in buying a car, starting an enterprise, and for education purposes, which increased by a percentage growth rate of 283.9% from 2013 to 2018. There was also increase in usage of remittance for household consumption (increased by 29%). A reduction in real estate in 2018 by 49.9% was also observed. This may be due to decline in real estate prices.

4.1.4.5 Proposed Projects and Investments in Kerala

The development in manufacturing sector and IT sector which will generate employment and is expected that a percentage of regional trips to shift to SilverLine. As per the Ascend 2020 conducted by the Government of Kerala, the investment in each sector and probable employment generation envisaged are provided in the **Table 4-11** below:

Table 4-11 Investment and employment generation in Manufacturing Sector

Sl. No.	Sector	Projects (in No.s)	Investment (in INR Cr.)	Direct Employment	Indirect Employment
1	Industrial Park, Logistics and MSMEs	34	26384	164010	332125
2	Infrastructure: Aeropolis and Ports	13	27565	8226	106300
3	Life science in Healthcare and Ayurveda	3	1575	25100	
4	Tourism and Hospitality	36	20586	17400	
5	Agro and Food Processing	5	377	750	
6	Mobility development and Electric Vehicles	10	73759	800	
	Total	**101**	**150245**	**216286**	**438425**

From the above table, it is observed that 1.5 lakh crore of investment and 2 lakhs direct employment and double the times in-direct employment. From the above, atleast 70% of the developments are proposed along SilverLine alignment.

Apart from manufacturing sector, IT sector is also expected for developments as technopark, infopark and cyberpark is envisaged for extension. The locations and SilverLine alignment are provided in the **Figure 4-14** below and the area earmarked for development along with employment generation is provided in **Table 4-6** below.

Figure 4-14 Proposed IT sector development area & SilverLine alignment

Table 4-12: Area and Employment generation in IT Sector

Sl. No.	Projects (in No.s)	Area (in Sq.ft)	Direct Employment	Indirect Employment
1	Technopark Phase III	5000000	35000	75000
2	Technocity	25000	3000	10000
3	World Trade Centre (Tvm)	2500000	15000	
4	Kollam Technopark	100000	1000	
5	Infopark Phase II Kochi	8000000	80000	
6	Infopark Trissur	330000	3000	15000
7	Infopark Chertala	240000	1500	
8	Cyberpark Kozhikode	300000	2000	
9	UL Cyberpark Kozhikode	62000	1500	
10	Cyberpark Kannur	250000	2500	
11	Cyberpark Kasaragod	25000	2500	
	Total	**16832000**	**147000**	**100000**

IT sector is expected to generate approximately 1.5 lakh employment.

The above development due to development of manufacturing sector and IT sector will also have impact on the GSDP and NSDP of the State and as the growth in GDP, GSDP and NSDP is already considered in estimated growth rate, the trips from development traffic due to other developments may not be considered to avoid duplication.

4.1.5 Tourism in Kerala

Kerala is one of the most popular tourist destinations in the country. Kerala is a leader in India when it comes to destination management, tourism promotion as well as tourist arrivals. Kerala tourism map is shown in **Figure** 4-15**.** The total annual tourists to Kerala constitute 48% of Kerala population.

Figure 4-15 Kerala Tourism Attraction Map

Source: Kerala's Approach to Tourism Development: A Case Study Ministry of Tourism & Culture, Government of India

The trends in annual domestic and foreign tourist arrivals in Kerala are shown in **Table** 4-13. About 0.42% and 6.35% increase was observed during 2017-18 for foreign and domestic tourist arrivals respectively.

Table 4-13: Yearly Tourist Arrival

Year	No. of Domestic Tourist Visits (in Lakhs)	% of Increase	No. of Foreign Tourist Visits (in Lakhs)	% of Increase	Total No. of Tourists (in lakhs)	% of Increase
2006	62.7	5.47	4.3	23.68	67.0	6.47
2007	66.4	5.92	5.2	2.37	71.6	6.84
2008	75.9	14.28	6.0	16.11	81.9	14.41
2009	79.1	4.25	5.6	-6.96	84.7	3.43
2010	86.0	8.61	6.6	18.31	92.5	9.25
2011	93.8	9.15	7.3	11.18	101.1	9.29
2012	100.8	7.41	7.9	8.28	108.7	7.48
2013	108.6	7.75	8.6	8.12	117.2	7.78
2014	117.0	7.71	9.2	7.6	126.2	7.71
2015	124.7	6.59	9.8	5.86	134.4	6.53
2016	131.7	5.67	10.4	6.23	142.1	5.71
2017	146.7	11.39	10.9	5.15	157.7	10.94
2018	156.0	6.35	11.0	0.42	167.0	5.94

Source: Kerala Tourism Statistics; Dept. of Tourism, Government of Kerala

The district wise tourist arrivals have been detailed in the **Table** 4-14. This data highlights the regional locations where the highest and lowest shares of tourists are attracted to. Maximum share of tourists (both Foreign and Domestic) are attracted to Ernakulam District (44.5% and 22.1% respectively).

Table 4-14: District-Wise Foreign and Domestic Tourist Arrivals

S No	District	Foreign Tourists (in 000's)			Domestic Tourists (in 000's)		
		2018	2017	% Variation over 2017	2018	2017	% Variation over 2017
1	Thiruvananthapuram	342.8	420.7	-18.53%	2712.4	2505.3	8.26%
2	Kollam	9.1	6.2	45.91%	400.2	381.8	4.82%
3	Pathanamthitta	2.0	2.0	-2.50%	192.8	164.5	17.22%
4	Alappuzha	95.5	75.0	27.30%	511.5	433.5	18.00%
5	Kottayam	43.3	32.4	33.81%	524.8	468.6	12.00%
6	Idukki	44.8	42.3	6.03%	1257.4	1090.1	15.35%
7	Ernakulam	488.2	454.0	7.53%	3446.9	3285.1	4.93%
8	Thrissur	11.3	10.8	5.18%	2497.3	2642.5	-5.50%
9	Palakkad	2.0	1.7	14.96%	509.9	474.2	7.53%
10	Malappuram	17.6	18.5	-4.56%	565.9	520.8	8.66%
11	Kozhikode	18.4	13.1	40.30%	1052.8	932.3	12.92%

S No	District	Foreign Tourists (in 000's)			Domestic Tourists (in 000's)		
		2018	2017	% Variation over 2017	2018	2017	% Variation over 2017
12	Wayanad	11.6	9.0	29.04%	888.1	815.6	8.89%
13	Kannur	5.8	5.1	12.49%	768.0	695.7	10.41%
14	Kasaragod	4.1	1.1	269.69%	276.6	263.5	4.99%
Total		1096.4	1091.9	0.42%	15604.7	14673.5	6.35%

Source: Kerala Tourism Statistics; Dept. of Tourism, Govt. of Kerala

The growth rate from 2017 to 2018 is minimal due to the State-wise flood during the months of August 2018. This may be the main reason for low footfall for foreign tourist. The details are provided in the Table 4-15 below:-

Table 4-15: Months-wise Arrival Details of Foreign Tourist (in 000's)

Sl. No	Month	2012	2013	2014	2015	2016	2017	2018	% of variation over previous year
1	January	106.3	113.6	119.9	130.5	136.5	150.8	168.0	11.39
2	February	103.2	115.4	127.2	132.9	141.1	135.1	152.0	12.52
3	March	75.5	86.0	93.2	100.2	107.0	107.1	120.7	12.67
4	April	61.3	66.4	72.4	76.7	78.1	82.6	85.5	3.46
5	May	30.5	32.6	36.3	39.6	38.0	49.1	45.4	-7.43
6	June	28.3	29.8	33.9	35.5	37.4	44.0	36.7	-16.56
7	July	43.0	45.8	48.6	51.7	56.7	72.6	68.9	-5.08
8	August	59.9	64.5	69.9	74.7	81.1	73.7	60.1	-18.46
9	September	47.4	51.0	54.2	57.6	62.6	54.7	44.8	-18.16
10	October	63.7	67.7	71.6	76.1	82.6	80.0	73.3	-8.37
11	November	78.8	83.5	87.7	89.9	96.2	107.0	99.3	-7.25
12	December	95.7	101.9	108.5	112.2	121.2	135.1	141.8	4.92
	Total	**793.7**	**858.1**	**923.4**	**977.5**	**1038.4**	**1091.9**	**1096.4**	**0.42**

Source: Kerala Tourism Statistics; Dept. of Tourism, Govt. of Kerala

From the above table, it is observed that August and September witnessed foreign tourist footfall reduction in the range of 18% and continued till November.

4.1.6 Transport Characteristics

4.1.6.1 Vehicle registration growth

Table 4-10 and Figure 4-7 present the growth in motor vehicles in Kerala since 2011 to 2018. Table 4-11 presents the district wise vehicle registration and Figure 4-8 indicates the composition of registered motor vehicles as on 31st March 2018.

Table 4-16: Growth of Motor Vehicles in Kerala Since 2011 to 2018

Category-wise Growth of Motor Vehicles in Kerala since 2010 to 2018									
Sl. No	**Type of Vehicles**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**	**2016-17**	**2017-18**
I	GOODS VEHICLES								
1	Four Wheeler and above	294395	322450	354296	373218	411347	419813	438709	452535
2	Three Wheelers including tempos	117266	128452	206901	140278	154610	136938	142792	147542
II	BUSES								
1	Stage Carriages	19897	21457	34161	28386	31286	42707	44291	43575
2	Contract Carriages/Omni buses	119150	124290	137731	132144	145645	64051	68036	71557
III	CARS AND STATION WAGONS								
1	Cars	1060861	1226691	1358728	1538246	1702926	2070665	2264904	2500994
2	Taxi Cars	163407	175638	128250	194358	214214	107567	118661	127011
3	Jeeps	73700	73700	74167	73700	73700	0	0	0
IV	THREE WHEELERS INCLUDING TEMPOS								
1	Autorickshaws	518741	575763	602547	663241	730999	610235	630609	649612
2	Motorized Cycle rickshaws	61	0	0	0	0	0	0	0

Category-wise Growth of Motor Vehicles in Kerala since 2010 to 2018									
Sl. No	**Type of Vehicles**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**	**2016-17**	**2017-18**
V	TWO WHEELERS								
1	Motorized Cycle	1017	0	0	0	0	0	0	0
2	Scooter/Motor Cycles	3610838	4127227	5041495	5288529	5828816	6472335	70771039	7796669
VI	TRACTORS	12224	13740	14183	15030	15297	14213	14236	14798
VII	TILLERS	5335	5399	5399	5414	5967	187	0	0
VIII	TRAILORS	2324	2407	2744	2411	2657	699	699	720
IX	OTHERS	46106	68325	88071	93011	103781	232403	236061	237678
	TOTAL	6045322	6865539	8048673	8547966	9421245	10171813	11030037	12042691
	Percentage increase over the previous Year	18%	14%	17%	6%	10%	8%	8%	9%

Source: RTO

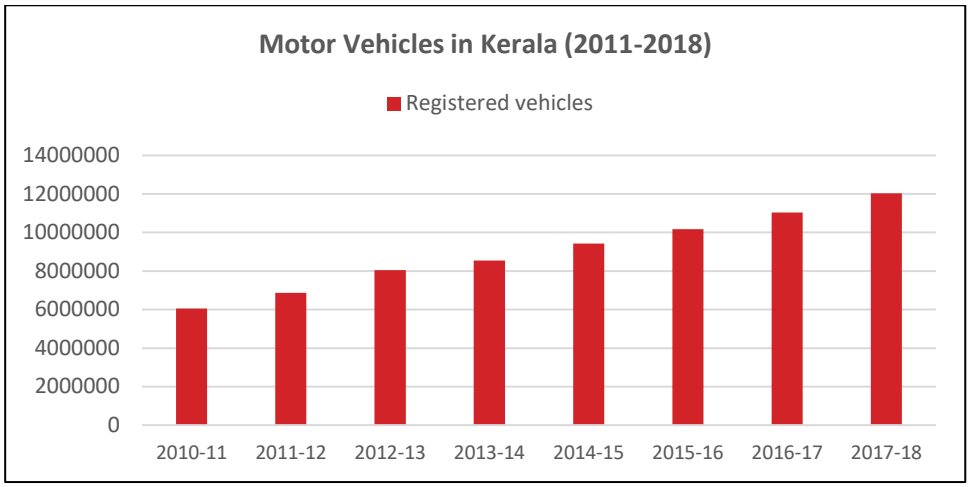


Figure 4-16 Motor Vehicles in Kerala (2011-18)

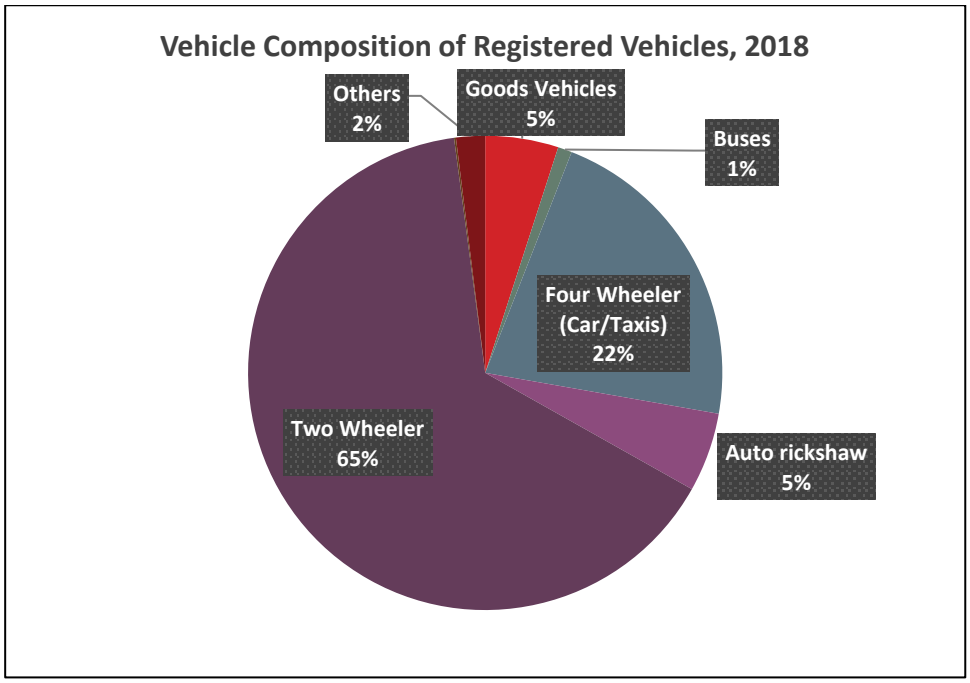


Figure 4-17 Vehicle Composition of Registered Motor Vehicles, 2018

Table 4-17: District Wise Vehicle Registration as on 31st March 2018

Sl. No.	District	Goods Vehicles	Buses	Four Wheeler (Car/Taxis)	Auto rickshaw	Two Wheeler	Tractors/Trailers	Others	Total
1	Thiruvananthapuram	52755	25374	340933	79687	998005	908	25752	1523414
2	Kollam	41143	6046	180542	52723	571909	685	15029	868077
3	Pathanamthitta	22248	3383	134246	26287	304492	364	11012	502032
4	Alappuzha	37239	6234	154028	29764	589315	757	13453	830790
5	Kottayam	41196	8362	213793	42957	418277	712	19520	744817
6	Idukki	16128	3175	61153	23171	129877	442	7677	241623
7	Ernakulam	92393	15360	419485	61079	1165472	2292	40787	1796868
8	Thrissur	56635	12522	252011	63050	840537	2347	21215	1248317
9	Palakkad	39980	6461	131449	46852	577799	3475	12601	818617
10	Malappuram	72895	8410	225172	80122	685834	1685	22940	1097058
11	Kozhikode	52530	7934	205424	55146	777561	485	15411	1114491
12	Wayanad	12426	1528	38854	14044	103784	755	4702	176093
13	Kannur	47531	8167	180593	49170	437227	330	16577	739595
14	Kasaragod	14978	2176	90322	25560	196580	281	11002	340899
	Total	**600077**	**115132**	**2628005**	**649612**	**7796669**	**15518**	**237678**	**12042691**

Source: RTO

4.1.6.2 Transport Sector Projects and Initiatives

The Govt. of Kerala has been a front runner in promoting public transport. However, in the recent past, a trend towards the personalised transport has been observed and therefore the Govt. has decided to revitalise public transport, and improve the road & rail infrastructure with focus on modern transportation systems and globally recognised best practices. The projects and initiatives can be divided into categories such as initiatives at Policy level, Urban transport, road infrastructure, rail infrastructure etc. The projects and initiatives are the following:-

At Policy Level:-

- **Approval of Kerala Metropolitan Transport Authority (KMTA) Bill:** As per the KMTA Act, Metropolitan Transport Authorities will be formed in three major cities - Thiruvananthapuram, Kochi and Kozhikode - and they will be declared urban mobility areas. The authority will be the umbrella body which is responsible for the development, operation, maintenance, monitoring and supervision of urban transport in urban mobility areas. As per the union government's Metro Rail policy, the formation of a Unified Metropolitan Transport Authority (UMTA) is a pre-requisite for Metro Rail projects. Integration of different modes of transport, seamless ticketing, fare revision, renovation of the bus transport system and other activities come under KMTA. Parking policy, intelligent transport facility and other amenities also come under the purview of authority. The main responsibility of KMTA are:-
    - Bring an integration of various departments related to the urban transport sector
    - Better, effective solutions to issues in urban transport sector
    - KMTA to prioritise actions based on future transport requirements
    - Overseeing urban transport policy for urban mobility areas
    - Managing network of integrated transport, including rail, boats, buses, cabs, rickshaws
- Draft Electric Vehicle (EV) Policy for Kerala is prepared
- Public Transport Policy for Kerala is under preparation
- Road Safety Action Plan is under preparation
- Private Participation in Passenger Trains: Ministry of Railways and National Institution for Transforming India (NITI) Aayog, Government of India are spearheading participation of private entities in operation of passenger trains on 100 routes. It is presently under tendering stage.
- Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME India) Scheme: The National Electric Mobility Mission Plan (NEMMP) 2020 is a National Mission document providing the vision and the roadmap for the faster adoption of electric vehicles and their manufacturing in the country. As part of the NEMMP 2020, Department of Heavy Industry formulated a Scheme viz. Faster

Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME India) Scheme in the year 2015 to promote manufacturing of electric and hybrid vehicle technology and to ensure sustainable growth of the same. Phase I focused on (i) Demand Creation, (ii) Technology Platform, (iii) Pilot Project and (iv) Charging Infrastructure. Phase II is expected to support adoption of 7000 EV buses through incentives and subsidy in operation.

The above policies and frameworks are required for improving the modal share of public transport in the state and also for promoting sustainable mobility. The policies also try to bring efficiency in operation of public transport.

Urban Transport Initiatives:

- **Expansion of Kochi Metro Rail:** the KMRL is operating MRTS in Kochi from Aluva to Thykudam as on March 2020. The work on the stretch from Thykudam to Petta is under construction and further extension up to Tripunithara is also under execution stage. The line from JLN Stadium to Kakkanad is under planning stage. K-Rail is also planning to have SilverLine Ernakulam Station at Kakkanad. This will have positive impact on the ridership of SilverLine due to addressing of first and last mile connectivity issues. The extension of line from Aluva to Kochi Airport and Angamali is also under planning stage (DPR stage).
- **Kochi Water Metro Project:** the project is under execution stage and will be implemented in two phases. Phase I with 7 routes and phase II with 9 routes connecting various islands in Kochi Region. The total length will be 76 Km and the line from Fort Kochi-Thevara-Vytilla-Kakkanad is expected to be operational by 2021.
- **Light Rail Transit (LRT)/MetroLite for Thiruvanthapuram:** Kerala Rapid Transit Corporation Limited (KRTL) is a Special Purpose Vehicle (SPV) of the Government of Kerala, set up for the implementation and subsequent operation and maintenance of the Metro Rail Systems in the city of Thiruvananthapuram. Presently the project is under planning stage. The City centre will be connected to Technocity in Pallipuram and there are also proposal to connect Thiruvanthapuram International Airport.
- **Light Rail Transit (LRT)/MetroLite for Kozhikode:** this project is also under planning stage is under the SPV – KRTL. The project is proposed to connect all major activity centres and mobility hubs in the city.
- **National Common Mobility Card (NCMC):** In line with central governments ‘one nation one card’, the GoK is in the process of enhancing the usage of NCM card as Driving Licence and to rebrand the card as “God’s Own Travel card (GOT?)” for Travel, Shopping and as a Driving Licence for the state of Kerala.

- **Other Urban Transport projects under Rebuild Kerala Initiative (RKI):** other urban transport projects under RKI are provided in the table below.

Table 4-18: Urban Transport Projects under RKI

Sl. No.	Key Activities	Status	Funding requirement* (INR Cr.)
1	Institutionalization of Green mobility corridors for promotion of Public Transport along National Highway (NH-66) – Kodungalloor to Eramalloor (52 km)	Feasibility Study Completed	580.35
2	Development of E- Bus corridors – Poothotta-Angamaly, 48 km (SH 15)	Feasibility Study Completed	677.51
3	Development of E- Bus Corridor as part of the Carbon Neutral Sabarimala (19 km)	Feasibility Study Completed	10 (Civil & EV Charging)
4	Constitution of "Kerala Bus Port Limited" & "Kerala Logistics Port Limited"	Concept note Planned	45
5	Development of Multimodal Logistics Port at Kalamassery	Concept note prepared	50
6	Development of e-Bus Corridor - Munambam-Goshree (link to Paravoor)	Concept note prepared	160
7	Development of New Generation Tram (LRT) between Thoppumpady and Goshree	Feasibility Study Completed	1000
8	Development of ICTT Rail Bus Project	Pre-Feasibility Study Completed	31

Most of the urban transport projects are focused on the three main cities of Ernakulam, Thiruvanthapuram and Kozhikode and may impact positively to the increase in ridership of SilverLine as it addresses the issue of first mile and last mile connectivity.

Road Infrastructure projects

As per the Hon. Chief Minister, GoK web portal, the major announcement for the road infrastructure projects are as follows:-

- Following international standards, National Highways will be widened an extra 45 metres, to ensure safety and security.
- A Special Safety Corridor (SSC), aiming at reducing road accidents by 30%, from Kazhakkuttam to Adoor (80 km) in the MC Road is being conceived initially, to be followed throughout the state at the next level.

- Flyovers in busy traffic junctions, such as Pattom, Sreekaryam and Ulloor, are under consideration and Rs. 2.73 Billion has been allocated to the construction of a flyover at Thampanoor.
- **Kerala Sustainable Transport Project (KSTP) Phase II:** this is World Bank funded project and the Stretches identified under the KSTP-II and the status of project are as provided in the table below.

Table 4-19: Road Projects under KSTP

Sl.No	Name of work	Revised contract amount (in Cr.)	Physical Progress (%)	Remarks
1	UG – 1 Kasaragod – Kanghangad Road (27.78 km)	114	99	Only finishing work left
2	UG – 2 Pilathara – Pappinisserry Road (20.90 km)	102	99	Only finishing work left
3	UG – 3A Thalassery – Kalarode Road (28.80 km) (Re-arranged)	156	62	Re arranged
4	UG – 3 B-Kalarode – Valavupara Road (25.20 km) (Re-arranged)	200	86	Re arranged
5	UG – 4-Chengannur Ettumanoor Road (45.40 km)	288	100	Completed
6	UG – 4 A Thiruvalla By pass (2.3 km)	37.03	46	Being Re arranged
7	UG -4B: Thiruvalla Town (Re-arranged) (2 Km)	7.7	84	Being Re arranged
8	UG – 6-Ponkunnam – Thodupuzha Road (50 km)	270	100	Completed
9	UG – 7-Perumbilavu – Perintalmanna Road (41 km)	210	100	Completed
10	UG -5-Ettumanoor – Muvattupuzha Road (40.96 km)	115.69	100	Completed
11	Safe Corridor Demonstration Project Kazhakuttam – Adoor	142.67	35	Work in progress

Source: KSTP

- Road infrastructure projects under RKI: the RKI has also identified projects for the improvement of transportation sector and the road projects are as provided in table below.

Table 4-20: Road Projects under RKI

Sector	Brief Description: Project/Investment (including key components/elements)	Department	Estimated Outlay in Rs. Crore
Rural Roads	Reconstruction and Rehabilitation of LSGD Roads using PMGSY standards covering 8 Districts. Construction contracts shall have 4-year maintenance period.	LSGD - Gram Panchayats	247.94
Urban Roads	Reconstruction and Rehabilitation of LSGD Roads using PMGSY standards covering 7 Municipalities. Construction contracts shall have 4-year maintenance period.	LSGD - Urban Local Bodies (ULBs)	86.9
Corporation Roads	Reconstruction and Rehabilitation of LSGD Roads using PMGSY standards covering 1 Municipal Corporation. Construction contracts shall have 4 year maintenance period.	LSGD - Thrissur Municipality	7.53
	Sub Total A		**342.37**
State highways and key Feeder roads	Mukkada Edamon Athikkayam Kakkudumon Mandhamaruthy Road	PWD	80
	Pathanamthitta- Ayroor- Muttukudukka Illathupadi - Muttukudukka Prakkanam - Prakkanam Elavumthitta - Kulanada Ramanchira - Thannikuzhy Thonniamala	PWD	112.46
	Edathua - Thayamkary- Kodupunna-Ramankary- Mancombu Kavalam Vikas Marg Road- Kannady Jn - Thattasserry-Neelamperoor-Kurichi Road	PWD	108
	Gandhinagar-Medical College-Babu Chazhikadan Road-Kottayam-Parippu Road-Athirampuzha Liessue-Kaippuzha-Mannanam-Pulikkuttissery-Parolickal-Muttappally Road	PWD	87.8
	Improvements to Painavu Thannikandom Asoakkavala road	PWD	84
	Idukki Neriyamangalm road	PWD	96.2
	Improvements to riding quality of Chemmannar Gap road	PWD	83.4
	Thrissur Kuttippuram Road (SH 69)	PWD	119.92
	Rahabilitation of Nenmara-Nelliampathy Road	PWD	122.84
	Improvements to Koyilandy Thamrassery Mukkam Areekode Edavanna (KTMAE- SH 34)	PWD	204.8
	Rehabilitation of Vythiri- Tharuvana road	PWD	83
	Mananthavady LAC- Improvements to Mananthavady - Vimalanagar - Kulathada - Valad HS - Periya road	PWD	99.2

Sector	Brief Description: Project/Investment (including key components/elements)	Department	Estimated Outlay in Rs. Crore
	Edoor – Companynirath - Angadikkadavu– Charal - Valavupara - Kacherikkadavu - Palathumkadav road	PWD	88
	Other key damaged highways and feeder roads and bridges in the districts of Idukki, Alappuzha and Patthinamthitta	PWD	630
	Sub Total B		**1,999.62**
	Grand Total		**2,341.99**

Source: Rebuild Kerala Development Programme, 2019

Improvement to all the NH, SH and other roads which are perpendicular to the alignment of the SilverLine shall have a positive impact on the ridership.

Rail Infrastructure Projects:

The major rail infrastructure projects prosed in Kerala are provided below in brief as the details are provided in chapter 1 and chapter 3 of this project.

- Sabari Railway Project - The new line connecting Angamali-Sabarimala.
- Doubling of line between Kayamkulam and Ernakulam via Allepy along with improvement in operating speed
- Doubling of line between Kottayam and Chingavanam
- Third line between Thiruvananthapuram and Thrissur
- New Line between Thirunavaya – Ponnani
- New Line from Nilambur to Nanjankode
- New siding at Kanjikode
- New line from Thalassery to Mysore: Project under the purview of K-Rail
- Electrification between Thiruvananthapuram and Kanniyakumari: The Cabinet Committee has also approved the construction of double line with electrification between Thiruvananthapuram in Kerala and Kanniyakumari in Tamil Nadu. The total length of the line will be 86.56 km while the estimated cost of the Project will be Rs.1431.90 crore and completion cost of Rs.1552.94 crore with 5% escalation per annum.

4.1.6.3 Impact of Transport Sector Projects and Schemes on Silverline

Impact of Road Projects on SilverLine

The improvement projects of NHs and SHs such as road widening and buindling of bypasses to NH 66, NH 766, SH 69, Kasaragod- Kanjagad Road etc., which are parallel to the alignment of the SilverLine shall have a negative impact on the ridership of SilverLine. This is mainly due to achieving higher journey speed and less journey time by private modes as well as buses that reduces the travel time savings. This in turn result in

negative shift due no change in cost savings. But, if the NHs and SHs are made to toll roads, due to higher costs, it may lead to positive shift to SilverLine.

In case of other NHs and SHs such as NH – 544, 85, 744, 966, 183, 183 A & 185 and SH perpendicular to SilverLine may act as feeder network. Any improvements such as widening will improve the travel time of first mile and last mile journey either by private vehicle or public transport. This may have a positive impact on the ridership of the SilverLine with additional provisions of inter-modal and interchange facilities with park and ride facilities.

So overall, the improvement to road project and the impact on the ridership assessment may not be significant and if considered will have only positive impact.

Impact of Operations of Electric Vehicles

India is embarking on the path of adopting electric vehicles in the country with the target of all electric vehicles fleet by 2030 as per the NITI Aayog. This seems quite ambitious considering at present the electric vehicle fleet is less than one percent. A review of global research and practices in electric mobility shows that electric vehicles are very costly as compared to conventional vehicles while the technology is also comparatively new to reach a significant level in the vehicular fleet in any country. As stated earlier, FAME was introduced by the Central Government and phase II focuses on deployment and operation of EV Buses in Indian cities through private operators and STUs shall remain regulators. The subsidy shall be disbursed based on per kilometer operational charges and only when STUs have introduced Gross Cost, Net Cost or Hybrid operational models involving private player for operations. In Kerala, the KSRTC invited tender for selection of private operators for wet leasing and operation of buses. But, did not materialize.

At present the KSRTC is operating 8-9 buses on wet lease for 10 years duration. The 9-metre-long eBuzz K9 buses were manufactured by Olectra Greentech in a tie-up with BYD. The wet lease bid was won by the Mumbai-based Maha Voyage LLP with a quote of ₹ 43.20 per km (lowest). As per cost analysis of KSRTC, it is anticipated to get a net balance of ₹6,500 per bus daily after electricity cost and wet lease amount.

The trial/pilot was done on route from Nilakal (a place near sabarimala 20Km away and hilly terrain) to Sabarimala during the previous Sabarimala season. Based on the data from transport department, on an average, the BEVs operated 360 km daily on the Nilackal-Pampa corridor. From the services, the KSRTC got a profit of ₹57 a km, including the electricity cost, out of the fare collection of ₹110 a km. Only 0.8 unit of electricity is needed for the BEV to run a kilometer. Compared to the operational cost of ₹31 a km for HSD-powered buses, the BEVs operational cost is ₹6. All these factors worked on trial basis but daily operations with large fleet and charging infrastructure is yet to be assessed to know the actual benefits.

As per UITP, the acceptance of electric and hybrid buses is slow in India, mainly due to cost factor. The average cost of hybrid or electric buses is 3-4 times higher than diesel

buses. Further, with the decrease in the cost of diesel, there is not much incentive for the operators to shift to hybrid or electric buses. The details of the buses under each segment and their cost is provided in the table below.

Table 4-21: Road Projects under KSTP

Segment	Diesel Buses		CNG	Hybrid Electric	Pure Electric
Model	Volvo 8400 (AC)	Tata STARBUS SLF 44 (AC/Non-AC)	Tata STARBUS LE CNG 18 (AC/Non-AC)	Tata STARBUS Hybrid (AC/Non-AC)	BYD K9 (AC)
Seats	32	44	18	32	31
Fuel Efficiency	2.2 Km/L	3.5 Km/L	2-3 Km/Kg	2.2-4 Km/L	1.5 kWh/Km
Fuel Cost	INR 23/Km	INR 15/Km	INR 13-19/Km	INR 10-17/Km	INR 10/Km
Range	484	560	260-390	286-520	249
Charging Time					3-6 Hr
Cost of Bus (in INR)	88 Lakhs	33 Lakhs	30 Lakhs	1.2-1.4 Cr.	2-3 Cr.

Source: UITP, 2019

From the above table, it is observed that the efficiency of buses and cost of operation is low but, the initial investment on the buses are atleast 3 times higher than normal ICE buses. So, regarding the impact of electric bus operations on SilverLine, it is also to be noted that the buses may have to operate on congested network in future and may reduce the benefits received from reduction in operational cost and ultimately fares. So the impact can be accounted only when the bus operations are stabilized and fares are reduced/subsidized by the STUs considerably.

Regarding private EVs such as cars, the capital cost is very high and the segments are under R&D stage. The electric cars are expected to launch with reduced cost from end of 2020. But, the infrastructure provision such as charging points are in nascent stage and may take longer duration to get stabilized. Also, as stated earlier, the vehicles have to use the same congested network in future. So, any benefits from the operational cost to the user is reduced by higher journey time.

Impact of Privatisation of Train Operations

This may bring efficiency and punctuality in operations, but may increase the fares. So, any impact on the SilverLine ridership due to operation of trains by private player is based on the fare setting.

Impact of Rail Infrastructure Projects

The doubling of lines, addition of 3rd line and improvement to curves and improving speed on the exiting railway operations will have impact on the ridership of the SilverLine. With no increase in fares, the passengers travelling by sleeper and 3rd AC class may not be willing to shift to SilverLine. But, if fares are increased, then no impact is expected as SilverLine provides higher travel time savings and cost savings to user is also low.

4.1.6.4 Issues and challenges in Road Transport Sector

As per the Department of Economics and Statistics, Kerala, "*most of the roads in the State do not have adequate width to address the existing level of traffic, only one fourth of the roads have either two lanes or four lane capacity while most of the other roads have single lane or intermediate lane capacity. In the case of National Highways also, only about 12 per cent of the roads have four lane capacities while the remaining roads have only two lanes or intermediate lane capacity. Bulk of the inter-city and interstate traffic is carried out by the National and State Highways which constitutes only 8 per cent of the total network. Considering the demand supply gap, there is a huge need for up gradation of existing road network. The existing road network has to undergo a qualitative improvement with the aim to reduce traffic congestion and delay, easy access to destinations and reduction in accident risks. Most of the PWD roads have to undergo massive upgradation with widening duly incorporating road safety features*".

Post Flood Scenario in Kerala:

As per the Kerala State Planning Board, "*About 2004 km of State Highways and 13,246 km of MDR across 14 districts have suffered varying degree of damages during the recent floods. The NH wing has estimated damage of about 580 km of NHs. The post flood impact analysis indicates heavy damages due to land slide/slips in the roads in four hill Districts of Idukki, Wayanad, Pathanamthitta and Palakkad, whereas roads in the seven Districts of Alappuzha, Thrissur, Ernakulam, Kozhikode, Malappuram, Kollam and Kottayam have sustained flash floods, erosion, water stagnation and other flood induced damages. The roads in Thiruvananthapuram, Kasaragod and Kannur Districts have also sustained minimal damage.*

1,090 km of State Highways and 6,527 km of MDRs have sustained light damages and would largely require pavement rehabilitation through patching, shoulder repairs and limited debris clearance. 734 km of State Highways and 6,463 km of MDRs have sustained medium to heavy pavement damages and would require re-laying of surfacing and limited repair of drainage, cross drainage and protection works. 179 km of SH and 256 km of MDR have been fully damaged and would require full pavement reconstruction, significant repair/reconstruction of drainage, cross drainage and slope protection works and limited road raising and new cross drainage works.

The overall cumulative damages for State Highways and MDR are estimated to be ₹7,647 crore and for NHs an additional need of ₹911 crore has been assessed. The State

Government has started providing immediate short-term repair of pavements and cross drainage structure, clearance of debris and temporary protection works to restore the access and keep the roads traffic worthy. The rehabilitation of the lightly damaged roads is largely through measures like pothole patching, to keep the roads traffic worthy.

7,197 km of roads (734 km of State Highways and 6,463 km of MDR) are severely damaged but are recoverable. 36 major and 178 minor bridges, 362 culverts, 43 km length of retaining wall and 169 km of roads side drainage works are severely damaged. Reconstruction of bridges/culverts needs to be assigned priority followed by adequate hill slope protection and flood protection works".

4.1.7 Road Accidents

Road accidents in the State are among the Nation's highest. Kerala stands third in terms of road accidents. Even though several initiatives have been taken by the Police to enforce road discipline and enforcement of rules by Motor Vehicles Department, road accidents are increasing. The bigger States like Uttar Pradesh, Gujarat and Rajasthan report far less number of accidents compared to Kerala.

Rapid motorization in the number of vehicles registered in the State, has created an intense pressure on the road infrastructure. In addition, the increased number of accidents in the State is also a growing concern. Most of the accidents are attributable to the fault of drivers as per records available with traffic police. However, deficiencies in road design also affect motor vehicles, a fact generally overlooked as bad road conditions. Road safety training for various categories of road users, rectification in road design, deficiencies in inclusion of road safety aspects in the planning and operation stages of road construction are the primary facts to be taken up for reducing accidents.

The trend of road accidents in Kerala since 2001 is shown in **Figure** 4-18 . District wise road accident details for year 2018(1st January to 31st December) is presented

Table 4-22. Details of cause of accidents in the year 2018 are given in **Table** 4-23.

The details of road accident by vehicle type involved is given in **Table** 4-24 and **Figure** 4-19.

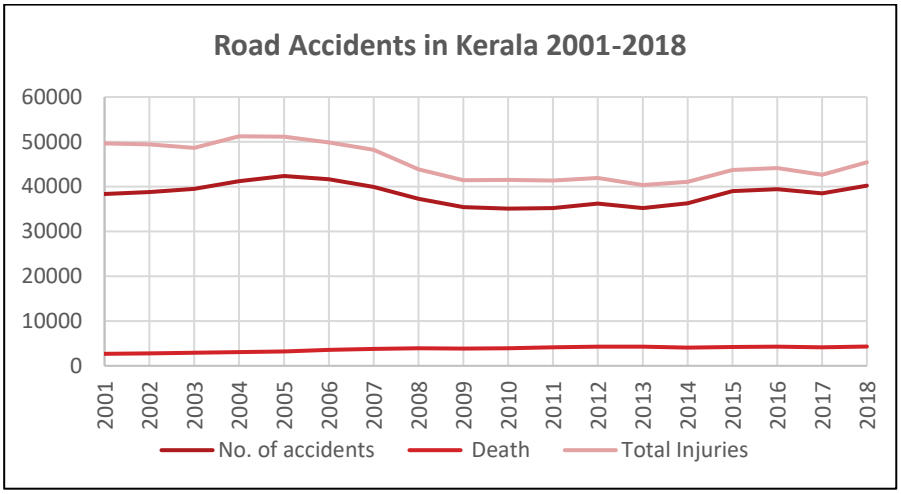


Figure 4-18 Trend of Road Accidents in Kerala 2001-2018

Source: keralapolice.org

Table 4-22: District Wise Road Accident Details (Year 2018)

District	Accident Type					Persons Involved			
	Fatal	Grievous	Minor	Non Injury	Total	Death	Grievous	Minor	Total
Thiruvananthapuram city	195	1880	178	53	**2306**	202	2033	714	**2949**
Thiruvananthapuram Rural	332	2728	124	39	**3223**	342	3068	592	**4002**
Kollam city	226	1526	140	48	**1940**	241	1691	306	**2238**
Kollam rural	220	1179	110	29	**1538**	228	1299	289	**1816**
Pathanamthitta	139	1190	197	1	**1527**	149	1320	456	**1925**
Alappuzha	348	2571	546	24	**3489**	373	2840	1294	**4507**
Kottayam	268	2023	467	166	**2924**	279	2289	915	**3483**
Idukki	82	808	241	51	**1182**	91	931	606	**1628**
Ernakulam city	131	1651	436	193	**2411**	141	1753	725	**2619**
Ernakulam rural	305	2650	617	13	**3585**	317	2800	1031	**4148**
Thrissur city	207	1538	364	113	**2222**	218	1670	923	**2811**
Thrissur rural	221	1554	338	72	**2185**	231	1695	807	**2733**
Palakkad	329	1456	537	89	**2411**	347	1574	1048	**2969**

District	Accident Type					Persons Involved			
	Fatal	Grievous	Minor	Non Injury	Total	Death	Grievous	Minor	Total
Malappuram	346	1677	217	183	**2423**	367	1911	690	**2968**
Kozhikode city	144	966	205	108	**1423**	154	1062	490	**1706**
Kozhikode rural	173	1210	183	108	**1674**	187	1372	549	**2108**
Wayanad	67	404	123	40	**634**	74	445	336	**855**
Kannur	217	1205	579	69	**2070**	233	1348	1243	**2824**
Kasaragod	119	498	369	28	**1014**	129	571	772	**1472**
Total	**4069**	**28714**	**5971**	**1427**	**40181**	**4303**	**31672**	**13786**	**49761**

Source: keralapolice.org

Table 4-23: Cause of Accidents (Year 2018)

Accidents Classified According to Type of Traffic Violation-2018									
Traffic Violation	No. of Accidents					No. of Persons			
	Fatal	GI	MI	NI	Total	Killed	GI	MI	Total
Over Speeding	2806	21613	4280	1077	29775	2985	23831	10158	36965
Jumping Red Light	8	74	17	6	105	8	81	32	121
Driving on Wrong Side	106	1035	250	64	1455	115	1161	552	1828
Unknown	560	2779	707	144	4191	582	3048	1482	5112
No Violation	567	3171	641	119	4498	589	3498	1446	5531
Drunken driving	22	42	76	17	157	25	53	116	194
Total	4069	28714	5971	1427	40181	4303	31672	13786	49761

Source: keralapolice.org

Table 4-24: Motor Vehicles Involved in Road Accidents in Kerala during 2018

Category-wise details of Motor Vehicles Involved in Road Accidents in Kerala during FY 2018 (April 2017- March 2018)											
Sl. No	District	KSRTC Buses	Other Buses	Goods Vehicles	Motor Cars	Jeeps	Auto Rickshaws	Two wheelers	Miscellaneous vehicles	Class not known	Total
1	Thiruvananthapuram City	100	43	88	679	12	313	2114	70	6	3425
2	Thiruvananthapuram Rural	127	87	201	847	31	372	3271	102	5	5043
3	Kollam City	45	101	158	638	11	165	1824	133	8	3083
4	Kollam Rural	64	81	124	453	27	174	1322	57	2	2304
5	Pathanamthitta	63	87	99	590	22	199	1318	59	9	2446
6	Alappuzha	99	147	342	956	12	320	3104	322	10	5312
7	Kottayam	95	223	236	1217	55	330	2290	117	19	4582
8	Idukki	54	95	89	450	106	181	761	30	4	1770
9	Ernakulam City	68	237	232	895	11	265	2203	135	9	4055
10	Ernakulam Rural	81	216	376	1037	44	368	3207	161	10	5500
11	Thrissur City	24	156	122	523	12	188	1260	71	1	2357
12	Thrissur Rural	66	218	282	935	25	325	2634	202	12	4699

Category-wise details of Motor Vehicles Involved in Road Accidents in Kerala during FY 2018 (April 2017- March 2018)											
Sl. No	District	KSRTC Buses	Other Buses	Goods Vehicles	Motor Cars	Jeeps	Auto Rickshaws	Two wheelers	Miscellaneous vehicles	Class not known	Total
13	Palakkad	33	213	276	707	49	332	2252	113	14	3989
14	Malappuram	56	230	343	919	56	338	1778	85	11	3816
15	Kozhikode City	37	255	124	512	27	149	1219	49	13	2385
16	Kozhikode Rural	41	208	171	524	44	206	1395	69	3	2661
17	Wayanad	29	55	69	251	29	97	494	22	4	1050
18	Kannur	50	208	189	628	46	346	1361	72	10	2910
19	Kasaragod	29	57	113	403	21	123	666	33	5	1450
	Total	1161	2917	3634	13164	640	4791	34473	1902	155	62837
	Percentage to Total	1.85	4.64	5.78	20.95	1.02	7.62	54.86	3.03	0.25	100
Source: State Crime Records Bureau											

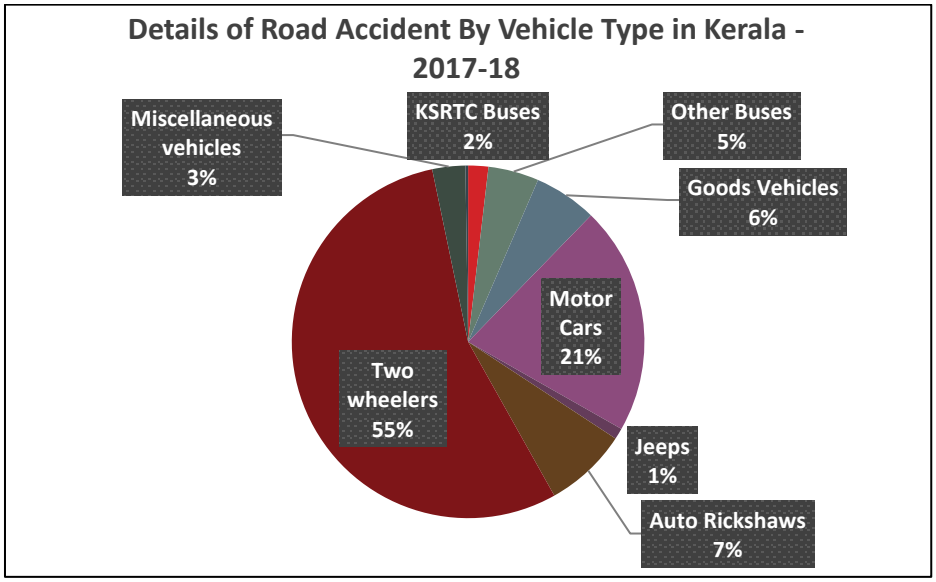


Figure 4-19 Details of Road Accident by Vehicle Type in Kerala, 2017-18

Infrastructure-wise accidents

Infrastructure-wise accidents can be categorised into road accidents, rail accidents and accidents at railway crossings. The details of road accidents are provided in the above sections. Regarding railway crossing accidents, as per NCRB, 2019 report, maximum railway crossing accidents were reported in Uttar Pradesh accounting for 44.3% (656 out of 1,481 cases) followed by Bihar (15.0%) (222 cases) and Kerala (12.2%) (180 cases). These States have also reported highest fatalities in railway crossing accidents, accounting for 46.0% (693 out of 1,507 deaths), 14.7% (222 deaths) and 11.8% (178 deaths) respectively during 2018.

Maximum railway accidents were reported in Maharashtra accounting for 23.0% (6,349 out of 27,643 cases) followed by Uttar Pradesh (11.8%) (3,272 cases). These two States have also reported highest fatalities in railways accidents, accounting for 15.5% (3,801 out of 24,545 deaths) and 12.6% (3,095 deaths) of total deaths in railways accidents respectively. Kerala railway figure stands at 16th position at 0.97%.

the comparative statement of road accident, railway accident and accident at railway crossing in Kerala is provided in the table below.

Table 4-25: Kerala - Infrastructure-wise accident 2018

Type	Road			Rail			Rail Crossing			Total		
Location	Cases	Injured	Died	Cases	Injured	Died	Cases	Injured	Died	Cases	Injured	Died
KERALA	40181	45458	4303	258	16	253	180	2	178	40619	45476	4734
(in %)	99	99.96	90.9	1	0.04	5.3	0	0.00	3.76	100	100	100

Source: NCRB, 2019

From the above table, in case of accident cases, it is observed that maximum accident cases are observed on road which is 99% followed by railway accidents (near to 1%). But in case of fatality, 90.9% is observed on road, 5.3% due to railway accident and 3.76% at railway crossing. It clearly indicates that, even though the cases are lower by railway accident or at crossing but fatalities rate is marginally higher.

4.2 DATABASE DEVELOPMENT

4.2.1 Approach and Methodology in Brief – Traffic Surveys

The aim of this report is to understand characteristics of existing transportation systems by conducting traffic surveys in the project corridor. The estimation of candidate traffic and patronage forecast requires well-defined traffic database containing relevant information concerning traffic flow characteristics. The broad methodology followed for the traffic surveys and analysis is presented in Figure 4-11. Candidate traffic for rail and car are also estimated in this report. Secondary data required for estimation of candidate traffic from bus is being collected from major bus depots and private bus operators.

Reconnaissance survey done along the project corridor helped in understanding general characteristics of the traffic along the corridor. It helped in identifying survey locations, and provided valuable insight during analysis.

Secondary data such as railway reserved passenger data, bus trips, toll traffic, fuel sales, railway goods traffic etc were collected .

Primary traffic surveys are conducted at pre-planned locations to identify existing demand on transportation systems and characteristics of existing traffic.

Data collected from primary and secondary sources are analysed in detail and used as the input for assessment of candidate traffic and SilverLine patronage forecast.

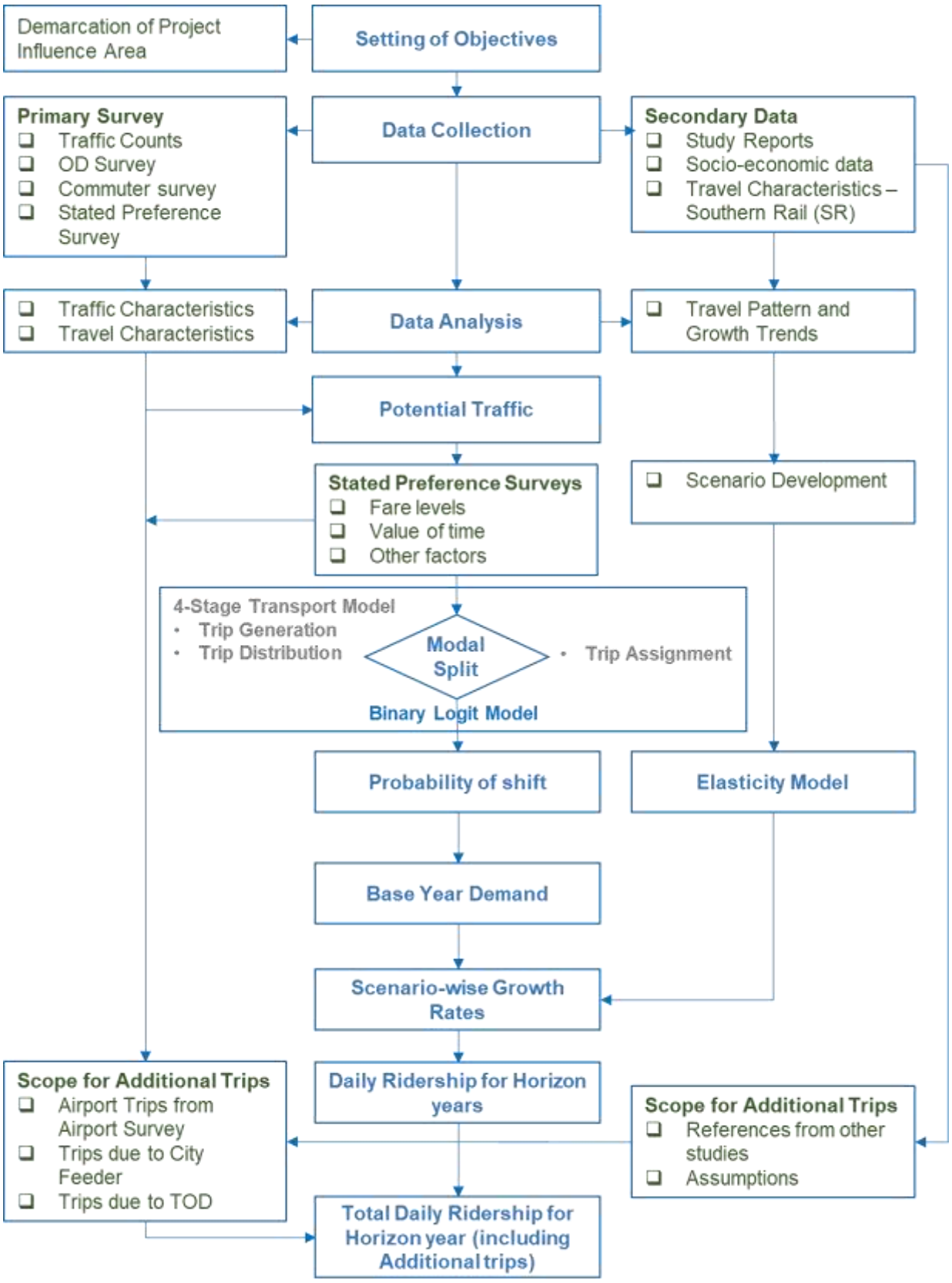


Figure 4-20 Approach and Methodology - Traffic Surveys

The growth rates were estimated based on the socio-economic data and also the vehicle registration data available from secondary data sources. The base year is considered as 2019-20, commissioning year as 2025-26 and horizon year as 2052-53. Apart from the above, for financial estimations, the projections was done till 2074-75 (FY 50). The growth rates projections was based on the assumption that, the growth rates during the 2052-53 was moderately reduced by 0.5% in successive 10 year interval.

The methodology was compared with other regional studies done in India and Kerala and the reports used as reference are:-

- Report 1: DPR for Mumbai-Ahmedabad High Speed rail Corridor
- Report 2: Updation of Transport model Study for RRTS corridor – NCRTC
- Report 3: Traffic Study for High Speed Rail from Thiruvanathapuram to Kasaragod – DMRC
- Report 4: RRTS Study for Trivandrum – Chengannur

The results are provided in the table below.

Table 4-26: Comparison Between Other DPRs

Parameters	Report 1	Report 2	Report 3	Report 4
Project	Mumbai -Ahmd HSR	RRTS – NCR (DGM)	HSR - Kerala	RRTS - TVM-CHNR
Year of Study	2015	2018	2017	2013
Catchment Population	17.2 Cr	5.9 Cr	3.3 Cr	0.7 Cr
Length (Km)	500	90	540	125
Mode Choice	Multinomial Logit	Binary Logit	Multinomial Logit	Not Mentioned
BY Ridership	40,000 (2023)	7,99,094 (2024)	85,332 (2020)	67,787 (2021)
HY Ridership	2,02,000 (2053)	13,13,914 (2051)	2,33,042 (2051)	1,56,462 (2051)
Feeder	Metro	Metro - 8 to 12% additional trips	Nil	Nil
TOD	No	7% Additional Trips	Nil	Nil
Operating Speed	320	100	300	
Fare / Km	4.61	1.82 - 2.73	5	0.80 - 2.0

It is observed that all the study has used the same methodology and processes for estimating the daily ridership. In this study, instead of a detailed transport demand model using various tools, excel-based mode choice modelling was used.

4.2.2 Secondary Data Collection

Secondary data such as Railway reserved passenger data, Bus trip details from major bus depots & private bus operators, Trip details of goods trains, Monthly traffic data at major toll plaza, Fuel sales along project corridor etc., are being collected from various departments. This chapter provides overview of the details of secondary data collected.

4.2.2.1 Railway Reserved Passenger Data

Railway passenger data were collected through Railways Datawarehouse, Centre for Railway Information Systems (CRIS) Reports. The data collected were compiled to identify candidate traffic from railways. Only trains crossing at least 3 SilverLine station were considered. Passenger traffic corresponding to only one direction has been compiled and demand in opposite direction is considered same. Also only AC, Sleeper and Chair Car passengers were considered as potential users. The passenger traffic data corresponds to the year 2018 (1st January to 31st December 2018).

Origin and Destination (OD) matrix were formulated based on data collected. Origin and destination of trips were classified as Internal or External based on their location. Locations within Kerala were termed internal and locations outside Kerala are termed External.

Both Internal to Internal and Internal to External traffic are included in candidate traffic. External to External traffic has been discarded.

4.2.2.2 Trains Considered for Analysis

List of trains passing through Kerala are considered for estimation of candidate traffic as shown in **Table** 4-27**.**

Table 4-27: List of Trains Considered.

Sl No.	Train No.	Train Name
1	10216	Madgaon Express
2	11098	Poorna Express
3	12076	Thiruvananthapuram Central-Kozhikode Jan Shatabdi
4	12081	Thiruvananthapuram- Kannur Janshatabdi
5	12202	LTT Garib Rath. KCVL to LTT
6	12217	Sampark Kranthi Exp. KCVL to Chandigarh
7	12224	Ernakulam - Mumbai LTT Duronto
8	12258	Yesvantpur Exp (Garib Rath). KCVL to YPR
9	12283	Ernakulam - Hazrat Nizamuddin Duronto

Sl No.	Train No.	Train Name
10	12431	Rajdhani Exp. TVC to NZM
11	12483	Amritsar Exp. From KCVL
12	12512	Rapti Sagar Express
13	12601	MGR Chennai Central - Mangaluru Central Mail (PT)
14	12617	Mangala Lakshadweep
15	12624	Chennai Mail From TVC
16	12625	Kerala Exp. TVC to Delhi
17	12643	Nizamuddin Exp.
18	12659	Gurudev SF Express (PT)
19	12685	MGR Chennai Central - Mangaluru Central SF Express (PT)
20	12696	TVC Chennai Exp.
21	12698	Thiruvananthapuram Central - MGR Chennai Central Weekly SF Express (PT)
22	12778	Kochuveli - Hubballi Weekly SF Express (PT)
23	12977	Maru Sagar Express
24	16302	Venad Express
25	16303	Vanchinad Express
26	16305	Cannanore Express
27	16307	Cannanore Express
28	16312	KCVL SGNR Exp.
29	16313	Cannanore Express
30	16316	Banglore Express From KCVL
31	16317	Himsagar Express (PT)
32	16319	Kochuveli - Banaswadi Humsafar Express
33	16332	Mumbai Express
34	16338	Okha Express
35	16342	Guruvayur Express

Sl No.	Train No.	Train Name
36	16343	Amritha Express (Via Palakkad Town) (PT)
37	16346	Netravathi Exp. TVC to LTT
38	16347	Mangalore Exp. From TVC
39	16349	Kochuveli - Nilambur Road Rajya Rani Express (PT)
40	16382	Kanniyakumari - Mumbai CSMT (Jayanti Janata) Express (PT)
41	16525	Kanniyakumari - KSR Bengaluru (Island) Express (PT)
42	16528	Kannur - Yesvantpur Express (PT)
43	16566	Mangaluru Central - Yesvantpur Weekly Express
44	16604	Maveli Express
45	16606	Ernad Exp. Nagercoil Jn. To Manglore
46	16629	Malabar Express (PT)
47	16650	Parasuram Exp. From Nagercoil to Manglore
48	16687	Navyug Express (PT)
49	16724	Ananthpuri Express QLN to Chennai Egmore
50	16855	Puducherry - Mangaluru Central Express (Via Salem) (PT)
51	16857	Puducherry - Mangaluru Central Express (Via Tiruchchirappalli) (PT)
52	17229	Sabari Express (PT)
53	17605	Mangaluru Central - Kacheguda Express (PT)
54	18568	Kollam - Visakhapatnam Weekly Express (PT)
55	19259	KCVL Bhavnagar Terminus Exp.
56	19261	Porbandar Express from KCVL
57	19331	KCVL Indore Exp. Train
58	19423	Tirunelveli - Gandhidham Humsafar Express
59	19577	Tirunelveli Jamnagar Express
60	22114	KCVL LTT Superfast Exp.
61	22149	Ernakulam - Pune Super-Fast Express

Sl No.	Train No.	Train Name
62	22208	Thiruvananthapuram - Chennai Duronto Express
63	22609	Mangaluru Central - Coimbatore Intercity SF Express
64	22620	Tirunelveli - Bilaspur Express
65	22633	Nizamuddin Exp. TVC to NZM
66	22637	West Coast SF Express (PT)
67	22640	Chennai Express
68	22641	Shalimar Express
69	22646	Ahilyanagari Express
70	22648	Thiruvananthapuram Central - Korba SF Express (PT)
71	22653	Nizamuddin Exp.
72	22655	TVC NZM Express
73	22659	Dehradun Exp. From KCVL
74	22678	Kochuveli- Yashwantpur AC Exp.
75	22851	Santragachi - Mangaluru Central Vivek Express (PT)

4.2.2.3 Traffic Data at Toll Plaza

Toll traffic data at Paliyekkara Toll Plaza is collected from NHAI through K-Rail for a period of three years. Mode wise traffic data, viz. LMV, LCV, Truck, Bus and MAV, were collected for FY17, FY18 and FY19.

Paliyekkara toll plaza lies on Thrissur- Edapally stretch on NH-544 (Old NH 47). It has a tollable length of 64.94 km. Operation of toll is under concessionaire, M/s Guruvayoor Infrastructure Private Limited.

Similar data was collected for Kumbalam Toll Plaza on Edapally- Vytilla- Aroor Section from January 2017 to October 2019 from NHAI through K-Rail. Mode wise traffic data, viz. Car, LCV, Bus, Truck, 3- Axle and 4-6 Axle/HCM/EME/MAV were collected. Kumbalam Toll plaza has a tollable length of 31.483 km. Concessionaire for Kumbalam toll is M/s Kochi Aroor Tollways Pvt Ltd.

4.2.2.4 Bus Passenger Trips Data

Bus Passenger trips data from Thiruvananthapuram Central were collected from KSRTC (Kerala State Road Transport Corporation) through K-Rail. Data were collected for the month October, 2019. About 1891 trips were operated in the month October, 2019.

All Fast, Superfast and Express Services are operated from Thiruvananthapuram Central. Whereas, only ordinary schedules are operating from Thiruvananthapuram city. Data collected includes Schedule number, Service type, Scheduled Kilometre, Operated Kilometre, Route, Total collection (in Rs.), total number of passengers, Earnings per Km and Earnings per bus. This data can be utilised in establishing candidate traffic from bus and potential shift from Bus.

Similar data is being collected from other major bus depots and private bus operators and can be used for establishing candidate traffic from bus.

4.2.2.5 Railway Goods Traffic data

Goods traffic data in Thiruvananthapuram division were collected from Ministry of Railways through K-Rail. The data collected have details of goods traffic data from April to October, 2019. Data collected includes Commodity, Station and consignor wise breakup of goods traffic originating from Thiruvananthapuram division. Details of destination stations to which goods traffic were booked from Thiruvananthapuram division and inward goods traffic are also compiled.

Details collected includes Number of Railway receipts, Number of Wagons, Weight in Tonnes, Freight charge and Net Tonne Kilometre of corresponding trips.

Similar data is being collected for Palakkad railway division also. This data will give insights on goods traffic currently being transported by rail.

4.2.2.6 Fuel Sales Data

Seasonal Correction Factors (SCF) can be derived based on fuel sales along the project corridor, in the absence of other reliable sources. Hence fuel sales at 47 petrol pumps throughout the project corridor were collected. Monthly sales for both petrol and diesel were collected. Fuel sales were noted in terms of Kilolitres. SCF derived from fuel sales can be used in estimation of Annual Average Daily Traffic (AADT) from ADT (Average Daily traffic) accommodating seasonal variation. SCF were calculated for September and October separately and used for surveys conducted in respective months.

4.2.3 Primary Traffic Surveys

Primary traffic surveys were conducted in the month of September and October 2019 by the Survey Agency, M/s P K Engineers, appointed by K-Rail. The results of these surveys form the basis for demand estimation and SilverLine patronage forecast.

4.2.3.1 Traffic Surveys Conducted

The following surveys were conducted in the months of September and October, 2019:

- Classified Traffic Volume Count (TVC) through Videography
- Vehicle Occupancy Surveys
- Origin and Destination (OD) surveys for Passenger and Goods vehicles

- Survey of Truck Operators, Cargo Forwarding Agencies and Railway Parcel Services
- Passenger Terminal OD Survey at identified Airport, Bus and Train Terminals
- Stated Preference/Willingness to Pay (WTP) Survey.

4.2.3.2 Reconnaissance Survey

Reconnaissance survey were done by Traffic Engineers along the project corridor, before conducting traffic surveys. Reconnaissance surveys helped in understanding general characteristics of the traffic along the corridor. It helped in identifying survey locations, and provided valuable insight during analysis. **Figure** 4-21 to **Figure** 4-23 shows pictures taken during reconnaissance.

Figure 4-21 Paliyekkara Toll Plaza

Figure 4-22 Toll Rate at Kumbalam Toll Plaza

Figure 4-23 Muzhapilangad Toll Plaza

4.2.3.3 Traffic Survey Schedule and Format

Schedule of surveys conducted as part of the study is shown in **Table** 4-28.

Table 4-28: Traffic Survey Schedule

Sr. No.	Location Name	Road	Traffic Volume Count		Occupancy Survey		OD Survey		Terminal (Bus, Rail/ Air) Survey		
			Start date	End date	Start date	End date	Start date	End date	Location Name	Start date	End date
1	Thottakadu	NH-66	18/9/19	21/9/19	19/9/19	20/9/19	20/9/19	21/9/19	Thiruvananthapuram Bus Stand	20/9/19	21/9/19
2	Kilimanoor	MC Road	18/9/19	21/9/19	19/9/19	20/9/19			Vytila Bus Stand	25/9/19	26/9/19
3	Karunagapally	NH-66	22/9/19	25/9/19	23/9/19	24/9/19	23/9/19	24/9/19	Thrissur Bus Stand	30/9/19	1/10/19
4	Sasthacotta	SH-37	18/9/19	21/9/19	19/9/19	20/9/19			Kozhikode Bus Stand	30/9/19	1/10/19
5	Adoor Bypass	MC Road	22/9/19	25/9/19	23/9/19	24/9/19			Thiruvananthapuram Railway Station	20/9/19	21/9/19
6	Ezninjillam	MC Road	22/9/19	25/9/19	23/9/19	24/9/19	24/9/19	25/9/19	Kollam Railway Station	23/9/19	24/9/19
7	Cherthala	Cherthala-Thanneermukkom Road	26/9/19	29/9/19	26/9/19	27/9/19			Ernakulam South Railway Station	25/9/19	26/9/19
8	Udayamperoor	SH-15	15/9/19	18/9/19	25/9/19	26/9/19			Kozhikode Railway Station	30/9/19	1/10/19
9	Kumbalam Toll Plaza	NH-16	26/9/19	29/9/19	26/9/19	27/9/19	27/9/19	28/9/19	Thiruvananthapuram Airport	10/10/19	11/10/19
10	Kumaranalloor	MC Road	15/9/19	18/9/19	25/9/19	26/9/19			Kochi Airport	27/9/19	28/9/19
11	Paliyekkara Toll Plaza	NH-544	26/9/19	29/9/19	26/9/19	27/9/19	27/9/19	28/9/19	Kozhikode Airport	28/9/19	29/9/19

Sr. No.	Location Name	Road	Traffic Volume Count		Occupancy Survey		OD Survey		Terminal (Bus, Rail/ Air) Survey		
			Start date	End date	Start date	End date	Start date	End date	Location Name	Start date	End date
12	Moothakunnam	NH-66	15/9/19	18/9/19	25/09/19	26/9/19			Kannur Airport	29/9/19	30/9/19
13	Gurupadapuri	NH-66	29/9/19	2/10/19	30/9/19	1/10/19	30/9/19	1/10/19			
14	Edappal	SH-69	15/9/19	18/9/19	25/9/19	26/9/19					
15	Cheruvannur	SH-28	15/9/19	18/9/19	25/9/19	26/9/19					
16	Azhinjillam	NH-66	29/9/19	2/10/19	30/9/19	1/10/19	30/9/19	1/10/19			
17	Muzhapilangad Toll Plaza	NH-66	3/10/19	6/10/19	3/10/19	4/10/19	3/10/19	4/10/19	Survey of Truck Operators, Cargo Forwarding Agencies & Railway Parcel Services	14/9/19	6/10/19
18	Kanhangad	NH-66	3/10/19	6/10/19	3/10/19	4/10/19	4/10/19	5/10/19	WTP (On Board Survey)	20/9/19	4/10/19

4.2.3.4 Classified Traffic Volume Count (TVC) Survey

Classified Traffic Volume Count Surveys were carried out at 18 identified locations across the study corridor. The surveys were organised during the month of September & October 2019. The traffic count surveys were conducted on 24 hours basis for 3 days (including a weekend). Videography were used for traffic count and vehicles were counted at 15 minutes interval. Directional classified traffic volume counts were analysed to study Average Daily Traffic (ADT), Peak Hour Flows and Traffic Composition. A map showing the location of traffic count and OD Surveys is shown in **Figure** 4-24**.**

Details of TVC survey locations are shown in **Table** 4-29. **Table** 4-30 gives vehicle classification adopted for volume count survey.

Table 4-29: Traffic Volume Count Survey Locations

Sl. No.	Location	Description	Road	Between SilverLine Stations	Type of Survey	Landmarks Nearby
1	**Thottakadu**	Near Chathampara	NH 66	TVM- Kollam	TVC and OD	Near Royal Garden Supermarket
2	**Kilimanoor**	Kilimanoor	MC Road	TVM- Kollam	TVC	Syndicate Bank, Kilimanoor. HP Petrol Pump (AK Fuels)
3	**Karunagapally**	Karunagappally, Near Pulliman Junction	NH 66	Kollam-Chengannur	TVC and OD	Indian Oil (Swagath Fuels). KC's Race Motors. Mozart Homes Store
4	**Sasthamcotta**	Between Bharanikavu and Sasthamcotta.	SH 37	Kollam - Chengannur	TVC	Near Vijaya Castle Hotel
5	**Adoor Bypass**	On Adoor Bypass	MC Road	Kollam - Chengannur	TVC	Travancore Support Services PVT. Ltd., City Building. Madathilazhikathu Tyres (MRF Franchisee)
6	**Ezhinjillam**	Between Thiruvalla and Changanassery	MC Road	Chengannur-Kottayam	TVC and OD	Near SBI, Ezhinjillam Branch
7	**Cherthala**	Between Cherthala and Kokothamangalam	Cherthala-Thanneermukkam Road	Kottayam-Ernakulam	TVC	Reliance Petrol Pump. Woodland's Restaurant
8	**Udayamperoor**	Near IOC Junction	SH 15	Kottayam-Ernakulam	TVC	Indian Oil Petrol Pump. Buddys Beauty Parlour and Salon. Anandhu Supermarket
9	**Kumbalam Toll Plaza**	Near Kumbalam Toll Plaza (NHAI)	NH 66	Kottayam-Ernakulam	TVC and OD	Kumbalam Toll Plaza
10	**Kumaranalloor**	Between Kottayam and Ettumanoor	MC Road	Kottayam-Ernakulam	TVC	Vajra Marbles and Granites. JB Timbers. IG Used Furniture Store
11	**Paliyekkara Toll Plaza**	Near PaliyekkaraToll Plaza (NHAI)	NH 544	Ernakulam-Thrissur	TVC and OD	Paliyekkara Toll Plaza

Sl. No.	Location	Description	Road	Between SilverLine Stations	Type of Survey	Landmarks Nearby
12	**Moothakunnam**	Between North Paravoor and Kodungalloor	NH 66	Ernakulam - Thrissur	TVC	Near Moothakunnam Bridge. Sree Govind Bharat Gas Agency
13	**Gurupadapuri**	Between Chavakkad and Thiruvathra	NH 66	Thrissur - Tirur	TVC and OD	Sree Viswanatha Temple. Jyothi Hotel
14	**Edappal**	Between Edappal and Naduvattom	SH 69	Thrissur - Tirur	TVC	Kumar Steels
15	**Cheruvannur**	Between Cheruvannur and Modern Bazar	SH 28	Tirur-Kozhikode	TVC	Ajantha Granites and Marbles
16	**Azhinjillam**	On Kozhikode Bypass	NH 66	Tirur-Kozhikode	TVC and OD	Le Sugar Dates and Chocolates. ChicHut. Coolmate Air Conditioning
17	**Muzhapilangad Toll Plaza**	Before Muzhapilangad Toll Plaza (Toll plaza for ROB)	NH 66	Kozhikode-Kannur	TVC and OD	Muzhapilangad Toll Plaza
18	**Kanhangad South**	Between Kanhangad and Kurundoor	NH 66	Kannur-Kasaragod	TVC and OD	Krishna Complex. Souhrida Vanitha Hotel. Pallikandathil Ayurvedic Centre

Table 4-30: Vehicle Classification Adopted

Motorized Traffic - Passenger	Motorized Traffic - Commercial
2 wheelers	Goods Auto
Auto Rickshaw	Light Commercial Vehicle (LCV)
Private Car (White Number Plate) : Car, Jeep, Van	Truck (2 – Axle Truck, 3 – Axle Truck)
Taxi (Yellow Number Plate) : Car, Jeep, Van	Multi Axle Truck (MAV), Container Trucks & Oil Tankers
KSRTC Bus AC	Tractor, Tractor with Trailer
KSRTC Bus Non AC	Others Goods
Private Bus AC	
Private Bus NON AC	
School Bus	
Mini Bus	
Others	

Figure 4-24 Locations of Traffic Volume Count and OD Surveys

4.2.3.5 Vehicle Occupancy Survey

Vehicle Occupancy surveys conducted as part of Traffic study, provided an insight about the number of passengers travelling by various modes at different locations. Vehicle occupancy surveys were conducted simultaneously with traffic count survey for 24 hours at all the 18 TVC locations on a typical working day. Survey was conducted by manual counting on random sampling basis and mode wise occupancy of vehicle were recorded for passengers travelling in both directions. For each direction, a minimum of 30% samples were collected.

4.2.3.6 Origin and Destination (OD) Survey

The Origin – Destination (OD) survey was conducted to understand the existing travel pattern on the project corridor and MC Road. OD survey of the passengers was conducted at 9 locations along the project corridor. The study area has been divided into 197 Traffic Analysis Zones (TAZ), based on which the analysis had been carried out.

OD Survey for both Passenger and Goods vehicles are conducted simultaneously with traffic counts on a week day for 24 hours. During this survey Trip Details viz. Origin and Destination, Trip length, Travel Cost, Travel Time, Occupancy, Purpose, Willingness to Shift to SilverLine, Extra Fare Willing to Pay for SilverLine etc are collected from passengers. In case of OD survey for Goods vehicles the drivers are asked about their Trip Details including Origin and Destination, Trip length, Commodity being carried, Tonnage, Transportation cost, Willingness to use Roll-On- Roll-Off (RORO) services on proposed SilverLine etc. These data is useful in determining travel pattern/characteristics and willingness to shift to SilverLine of passenger and goods vehicles.

4.2.3.7 Stated Preference/ Willingness To Pay (WTP) Survey

Onboard Willingness to Pay survey were carried out on Buses & Trains that ply on the identified study corridor and at Airports. This survey was conducted to understand the user perception, Travel Characteristics and Willingness to Shift to SilverLine System. Using the questionnaires, the user was enquired regarding their socio-economic characteristics and travel pattern. Designed as a Stated Preference Survey, WTP would help in assessing the user's willingness to shift to SilverLine with several important factors such as Cost, Time and Frequency, that may affect the decision to choose the mode of transport for commuting. The response of the same is being used for evaluating the shift to SilverLine from other competing modes.

The trains and buses that ply on the study corridor were identified for the purpose and surveyed. Each Scenario in the questionnaire refers to a set or combination of Travel Cost, Time and Frequency for both SilverLine and the present mode, *for a trip length of 200 km (based on approximate distance between Thiruvananthapuram & Ernakulam and Ernakulam & Kozhikode)*. Each of the six scenarios consists of variations in Travel Time, Travel Cost and Frequency of SilverLine Service. The six scenarios considered for the survey are given in **table 4-26.**

Table 4-31: WTP Survey Scenarios for Average Trip Length of 200 Km

Scenario	Mode	Fare (Rs)	Frequency (Minutes)	Travel Time (Minutes)
Mode	AC Train/ AC Bus	300	120	240
Mode	Sleeper/ Non AC Bus	150	90	240
1	SilverLine	500	30	90
2	SilverLine	500	60	

Scenario	Mode	Fare (Rs)	Frequency (Minutes)	Travel Time (Minutes)
3	SilverLine	700	30	
4	SilverLine	700	60	
5	SilverLine	900	30	
6	SilverLine	900	60	

The user was asked to respond to the scenarios, whether under the particular scenario he/she would be willing to Shift to SilverLine from their present mode. The responses are classified into following distinct categories:

1 Definitely travel by present mode,

2 Probably Travel by present mode,

3 Indifferent,

4 Probably by HSR,

5 Definitely by HSR,

6 No response.

4.2.3.8 Passenger Terminal OD Survey

The interview of passengers at identified terminals (4 Airports, 4 Bus Terminals and 4 Train Terminals) were conducted to establish existing Travel Pattern of Commuters. Details like Trip Origin, Destination, Access/ Dispersal Mode Used (Last Mile Connectivity), Willingness to Shift to SilverLine, personal details like Occupation etc of Air, Bus and Rail Passengers are collected. Separate questionnaires were used for Boarding and Alighting passengers and survey was conducted for 24 hours on a typical working day. **Table** 4-32 gives the list of locations were passenger OD Survey was conducted

Table 4-32: Passenger Terminal OD Survey Locations

Sl. No.	Terminal Survey Location
1	Thiruvananthapuram Airport
2	Thiruvananthapuram KSRTC Bus Terminal
3	Thiruvananthapuram Railway Station
4	Kollam Railway Junction
5	Cochin International Airport
6	Ernakulam South Railway Station

Sl. No.	Terminal Survey Location
7	Ernakulam – Vytila Bus Terminal
8	Thrissur KSRTC Bus Terminal
9	Kozhikode Airport
10	Kozhikode Railway Station
11	Kozhikode Private Bus Terminal
12	Kannur Airport

4.2.3.9 Survey of Truck Operators, Cargo Forwarding Agencies and Railway Parcel Services

Survey of truck operators and cargo forwarding agencies, located in Kerala and border districts of Tamil Nadu and Karnataka, was conducted to collect information on the operational characteristics of goods vehicles. The information being collected includes type and volume of cargo transported, Origin - Destination, Operational Cost and Willingness to Shift to RORO facilities at specified rates. To identify characteristics of existing cargo being transported by Railway, surveys are being conducted at Railway Parcel Services at 5 major cargo handling stations in Kerala.

The objective was to cover at least 100 truck operators and 20 freight forwarding agencies located in Kerala, and Border districts of Tamil Nadu and Karnataka. 114 truck operators and 27 freight forwarding agencies were covered during survey

Details of Railway Parcel Service were collected from the following stations:

- Central Railway Station, Thiruvananthapuram
- Kollam
- South Ernakulam
- Kozhikode
- Kasaragod
- Thrissur
- Kannur

4.3 DATA ANALYSIS – TRIP CHARACTERISTICS

Analysis of Traffic surveys conducted and secondary data collected as part of DPR preparation are summarized in this chapter. The results of these analysis form the basis of candidate traffic estimation and patronage forecast of SilverLine.

4.3.1 Classified Traffic Volume Count (TVC) Survey

Classified Traffic Volume Count Surveys were carried out across the study corridor. Traffic Volume counts conducted at 18 locations along the project corridor provided an insight to the traffic intensity and composition on various stretches of the corridor. **Table** 4-33 presents the average 24 hours traffic volume, Average Daily Traffic (ADT) (year 2019) observed at all the 18 locations.

Table 4-33: Average Daily Traffic (ADT)

Sl.No	ID	Location Name	Road Stretch (Direction):	Direction Wise Vehicles	Total Vehicles	Direction wise PCU	Total PCU
1	TVC 01	Thottakadu	Towards Kollam	19,561	38,673	20,063	39,736
			Towards Thiruvananthapuram	19,112		19,673	
2	TVC 02	Kilimanoor	Towards Kollam	15,498	32,713	15,066	32,009
			Towards Thiruvananthapuram	17,215		16,943	
3	TVC 03	Karunagapally	Towards Chengannur	31,495	61,759	27,032	53,716
			Towards Kollam	30,264		26,684	
4	TVC 04	Sasthamcotta	Towards Chengannur	11,344	22,448	9,029	17,957
			Towards Kollam	11,104		8,928	
5	TVC 05	Adoor Bypass	Towards Chengannur	9,396	18,145	9,490	18,478
			Towards Kollam	8,750		8,988	
6	TVC 06	Ezhinjillam	Towards Chengannur	13,939	28,473	14,637	29,930
			Towards Kottayam	14,535		15,293	
7	TVC 07	Cherthala	Towards Ernakulam	10,365	20,447	7,881	15,641
			Towards Kottayam	10,083		7,761	
8	TVC 08	Udayamperoor	Towards Ernakulam	17,080	32,801	14,645	28,235
			Towards Kottayam	15,720		13,590	
9	TVC 09	Kumbalam Toll Plaza	Towards Ernakulam	29,488	59,014	29,319	59,410
			Towards Kottayam	29,526		30,092	
10	TVC 10	Kumaranalloor	Towards Ernakulam	23,010	45,229	23,759	46,609

Sl.No	ID	Location Name	Road Stretch (Direction):	Direction Wise Vehicles	Total Vehicles	Direction wise PCU	Total PCU
			Towards Kottayam	22,218		22,850	
11	TVC 11	Paliyekkara Toll Plaza	Towards Thrissur	38,822	77,639	45,321	90,382
			Towards Ernakulam	38,816		45,061	
12	TVC 12	Moothakunnam	Towards Thrissur	18,816	36,764	17,294	33,760
			Towards Ernakulam	17,947		16,465	
13	TVC 13	Gurupadapuri	Towards Tirur	6,445	13,213	6,114	12,751
			Towards Thrissur	6,769		6,638	
14	TVC 14	Edappal	Towards Tirur	18,701	38,352	16,272	33,717
			Towards Thrissur	19,651		17,445	
15	TVC 15	Cheruvannur	Towards Kozhikode	21,555	42,827	19,841	39,432
			Towards Tirur	21,272		19,591	
16	TVC 16	Azhinjillam	Towards Kozhikode	25,942	51,484	26,596	52,824
			Towards Tirur	25,542		26,228	
17	TVC 17	Muzhapilangad Toll Plaza	Towards Kannur	14,342	28,702	16,748	33,465
			Towards Kozhikode	14,360		16,717	
18	TVC 18	Kanhangad South	Towards Kasaragod	12,306	25,047	15,000	30,313
			Towards Kannur	12,740		15,313	

It can be observed from the **Table** 4-33 that the highest traffic flow of 77,639 vehicles (90,382 PCUs) was observed at Paliyekkara Toll Plaza (Ernakulam to Thrissur-Location TVC 11). The lowest flow of 13,213 vehicles (12,751 PCUs) was observed at Gurupadapuri (Tirur to Thrissur-Location 13.

Figure 4-25 represents traffic intensity along the corridor based on ADT in PCUs.

Figure 4-25 Representation of Traffic Intensity along Project Corridor

The Passenger Car Unit (PCU) values adopted for the study are as per Guidelines of Indian Roads Congress and the same is shown in **Table** 4-34.

Table 4-34: PCU Values for Different Vehicle Classification

Car/Taxi	Mini-Bus	Bus	School Bus	2 Wheeler	Passenger/ Goods Auto	LCV	Truck	MAV/ Tractor+ Trailer	Others
1	1.5	3	3	0.5	1	1.5	3	4.5	6

4.3.2 Seasonal Correction Factor (SCF)

Seasonal Correction Factors which are derived considering fuel sales at petrol pumps throughout the project corridor are used for estimation of Annual Average Daily Traffic (AADT). The estimated SCF at various petrol pumps is presented in **Table** 4-35. SCF are calculated separately for petrol and diesel vehicles for the month of September and October 2019.

Table 4-35: Seasonal Correction Factors (SCF)

Sl No.	Petrol Pump	September		October	
		SCF Petrol	SCF Diesel	SCF Petrol	SCF Diesel
1	Abdhul Vaheed Fuels, Navikulam	1.03	1.03	1.07	1.00
2	Anandam Fuels Center, Mannglapurm	0.99	1.02	0.99	0.98
3	Asoka Fuels Thalikulam, Thrissur	1.00	1.01	1.02	1.00
4	Bala krishana Fuels, Kottiamkulam	0.98	0.99	1.02	1.01
5	Benzy Fuels, Ayyottihira	1.01	0.99	1.02	1.01
6	Calicnt Mananthalathazham, Palazhr	1.00	1.00	1.00	0.99
7	Charanga TTU Fuels S.L Puram	0.99	1.00	1.03	1.00
8	Daya Petroleum, Koyilandy	0.99	1.01	1.01	0.99
9	Dev Fuels, Sakthikulangara, Kollam	0.98	1.04	1.01	0.95
10	Dilkhus Petrolium, Calicut	0.99	0.99	1.02	1.02
11	Emcee Fuels, Pilathara	1.02	1.10	1.03	1.03
12	Emmey Fuels, Triprayar	1.01	0.99	0.98	1.00
13	Frince Fuels, Acoppuzha	0.98	0.99	0.97	0.98
14	Hi point Fuels, Pathirapally	0.99	0.99	1.01	1.00
15	IBP Auto Services, Vettichira	1.04	1.09	0.93	0.89
16	K.K Mohamad and Company, Haripad	1.04	0.99	1.02	1.01
17	Kandoth, Payyanur	1.07	0.97	1.05	1.00
18	Karivellur Fuels	1.03	1.13	1.01	1.00
19	KM. Poothukaran Fuels, Engandiyur	0.98	0.99	1.02	1.00
20	Kolappuram Petrolium Agency	1.03	1.04	1.01	0.99
21	Koyilandy	1.03	1.17	1.06	1.18
22	KV Fuels, Purakkad	1.00	1.01	1.01	0.98
23	Laila Agencies , Pallippuram	0.99	0.96	0.97	1.08
24	Laxmi Selas, Calicut	1.00	1.01	0.99	0.99
25	M.S George and Company, Purakkad	1.04	1.02	1.00	0.99

Sl No.	Petrol Pump	September		October	
		SCF Petrol	SCF Diesel	SCF Petrol	SCF Diesel
26	MadhavamVam Fuels, Puthupanam, Vadakara	0.99	1.00	0.98	1.00
27	Mambra Fuels, Edamuttam	0.99	1.00	1.03	1.01
28	Masteris Service Station	1.00	1.01	1.00	0.99
29	Matesh Fuels, Kalavoor	1.01	0.99	1.01	1.02
30	Modern Fuels, Kayamkulam	1.00	0.99	1.00	0.99
31	Nada Purayil Fuels, Nangiar kulangara	1.01	1.01	0.99	1.00
32	Nass Fuels, Kalam Kullam	1.00	1.01	0.99	0.99
33	Panannakkad	1.09	1.08	1.06	1.00
34	Royal Fuels, Chathannoor	1.02	1.00	0.97	1.01
35	Saeeram Petroleum	1.00	1.00	1.00	0.99
36	Shanti Fuels, Karuvatta	1.01	1.00	0.99	0.98
37	Shree Vinayaka Fuels, S.N Puram	1.00	0.98	0.99	0.99
38	T.C Fuels, Alappuzha	1.00	0.98	1.00	1.00
39	Thariyal Fuels, Athirthhi	1.00	1.00	0.98	0.99
40	United Trading Corporation, Monvpeedika	0.99	1.07	0.98	1.07
41	Vava Fuels, Eramallore	1.00	1.00	1.01	1.01
42	Visham Fuels Kochubila, Alamcode	1.00	0.99	0.99	1.00

Average of SCF obtained at all the fuel stations is considered as representative value for the study and adopted SCF values are given in **Table** 4-36**.**

Table 4-36: Adopted SCF Values

Sl No.	Sections	September		October	
		SCF_Petrol	SCF_Diesel	SCF_Petrol	SCF_Diesel
1	Kozhikode - Kannur	1.00	1.03	1.02	1.03
2	Chengannur - Kottayam	1.01	1.00	1.00	0.99
3	Ernakulam - Thrissur	0.99	1.01	1.00	1.01
4	Kannur - Kasaragod	1.05	1.07	1.04	1.01
5	Kottayam - Ernakulam	0.99	0.99	1.01	1.01

Sl No.	Sections	September		October	
		SCF_Petrol	SCF_Diesel	SCF_Petrol	SCF_Diesel
6	Kollam - Chengannur	1.00	1.00	0.99	0.99
7	Tirur - Kozhikode	1.02	1.04	0.96	0.94
8	Thrissur - Tirur	1.01	0.99	1.01	1.00
9	Thiruvananthapuram - Kollam	1.00	1.01	1.00	1.00

4.3.3 Average Annual Daily Traffic (AADT)

Annual Average Daily Traffic (AADT) was estimated considering the seasonal correction factors which are derived considering fuel sales along the corridor. AADT estimated is given in **Table** 4-37

Table 4-37: Annual Average Daily Traffic

Sl. No.	Location ID	Location	Vehicles		PCU Vehicles	
			ADT	AADT	ADT	AADT
1	TVC 01	Thottakadu	38673	38955	39736	40107
2	TVC 02	Kilimanoor	32713	32948	32009	32298
3	TVC 03	Karunagapally	61759	61759	53716	53716
4	TVC 04	Sasthamcotta	22448	22448	17957	17957
5	TVC 05	Adoor Bypass	18145	18145	18478	18478
6	TVC 06	Ezhinjillam	28473	28561	29930	29974
7	TVC 07	Cherthala	20447	20243	15641	15485
8	TVC 08	Udayamperoor	32801	32473	28235	27952
9	TVC 09	Kumbalam Toll Plaza	59014	58424	59410	58816
10	TVC 10	Kumaranalloor	45229	44776	46609	46142
11	TVC 11	Paliyekkara Toll Plaza	77639	77858	90382	91007
12	TVC 12	Moothakunnam	36764	36776	33760	33920
13	TVC 13	Gurupadapuri	13213	13212	12751	12689
14	TVC 14	Edappal	38352	38320	33717	33555
15	TVC 15	Cheruvannur	42827	44089	39432	40783

Sl. No.	Location ID	Location	Vehicles		PCU Vehicles	
			ADT	AADT	ADT	AADT
16	TVC 16	Azhinjillam	51484	53154	52824	54742
17	TVC 17	Muzhapilangad Toll Plaza	28702	29464	33465	34420
18	TVC 18	Kanhangad South	25047	25546	30313	30740

4.3.4 Vehicle Composition

Classified Traffic Volume Counts also provided valuable insight into the vehicular composition of the traffic in the study area. The overall traffic composition in terms of AADT (total number of vehicles) is shown in **Figure** 4-26

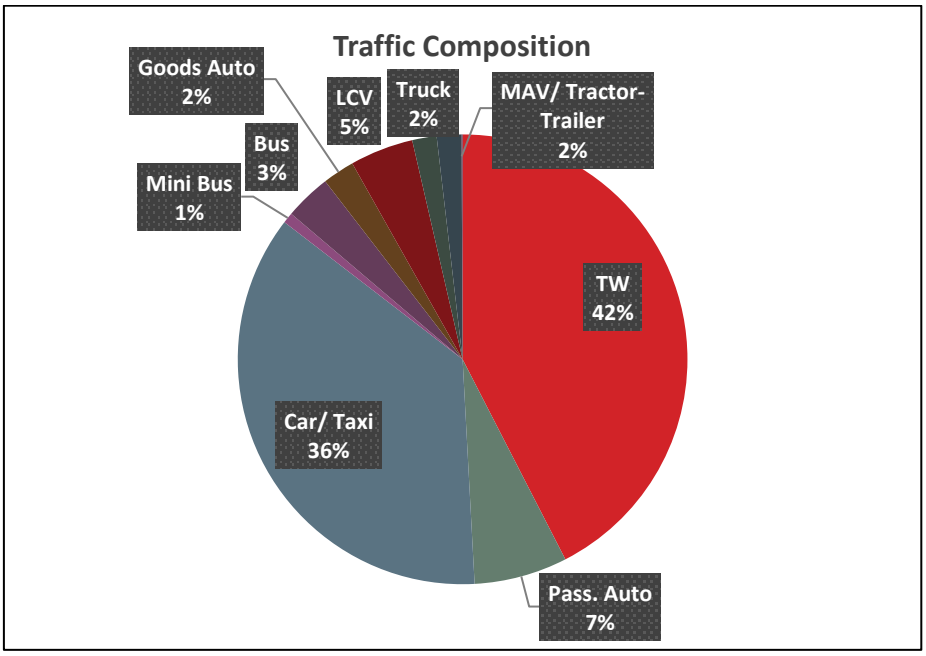


Figure 4-26 Overall Traffic Composition

Vehicular composition recorded at all locations during the traffic volume count showed that majority of the traffic comprised of cars and two-wheelers(Cars-36% and TW-42%).

Table 4-27 shows details of the classified vehicular traffic volume observed at each of the survey Locations

Table 4-38: Location Wise Vehicular Composition (%)-AADT

Sl. No.	ID	Location Name	TW	Pass. Auto	Car/ Taxi	Mini Bus	Bus	Goods Auto	LCV	Truck	MAV/ Tractor-Trailer	Others
1	TVC 01	Thottakadu	12423	2030	18618	379	1676	1456	1283	679	495	10
			31.8%	5.2%	47.7%	1.0%	4.3%	3.7%	3.3%	1.7%	1.3%	0.0%
2	TVC 02	Kilimanoor	10557	2596	15905	293	1198	1096	733	396	251	3
			32.0%	7.9%	48.2%	0.9%	3.6%	3.3%	2.2%	1.2%	0.8%	0.0%
3	TVC 03	Karunagapally	32208	3722	19613	345	1605	2067	1269	749	724	2
			51.7%	6.0%	31.5%	0.6%	2.6%	3.3%	2.0%	1.2%	1.2%	0.0%
4	TVC 04	Sasthamcotta	13880	1238	5430	88	754	681	299	142	120	5
			61.3%	5.5%	24.0%	0.4%	3.3%	3.0%	1.3%	0.6%	0.5%	0.0%
5	TVC 05	Adoor Bypass	5320	677	9931	159	137	102	1260	427	250	60
			29.0%	3.7%	54.2%	0.9%	0.7%	0.6%	6.9%	2.3%	1.4%	0.3%
6	TVC 06	Ezhinjillam	8860	1182	13992	254	1178	1316	852	595	520	3
			30.8%	4.1%	48.7%	0.9%	4.1%	4.6%	3.0%	2.1%	1.8%	0.0%
7	TVC 07	Cherthala	12591	2032	4389	91	397	672	255	122	66	5
			61.1%	9.9%	21.3%	0.4%	1.9%	3.3%	1.2%	0.6%	0.3%	0.0%
8	TVC 08	Udayamperoor	16225	2187	11416	306	1061	1073	433	216	174	1

Sl. No.	ID	Location Name	TW	Pass. Auto	Car/ Taxi	Mini Bus	Bus	Goods Auto	LCV	Truck	MAV/ Tractor-Trailer	Others
			49.0%	6.6%	34.5%	0.9%	3.2%	3.2%	1.3%	0.7%	0.5%	0.0%
9	TVC 09	Kumbalam Toll Plaza	27070	2326	19132	471	1531	2954	2662	1720	1695	6
			45.4%	3.9%	32.1%	0.8%	2.6%	5.0%	4.5%	2.9%	2.8%	0.0%
10	TVC 10	Kumaranalloor	15896	3378	20157	294	2549	232	2052	530	527	43
			34.8%	7.4%	44.1%	0.6%	5.6%	0.5%	4.5%	1.2%	1.2%	0.1%
11	TVC 11	Paliyekkara Toll Plaza	28036	3601	28886	603	3025	680	7951	2086	3439	99
			35.8%	4.6%	36.8%	0.8%	3.9%	0.9%	10.1%	2.7%	4.4%	0.1%
12	TVC 12	Moothakunnam	17878	1772	12871	371	1071	311	1851	478	478	14
			48.2%	4.8%	34.7%	1.0%	2.9%	0.8%	5.0%	1.3%	1.3%	0.0%
13	TVC 13	Gurupadapuri	6569	1776	2976	172	411	529	252	307	340	0
			49.3%	13.3%	22.3%	1.3%	3.1%	4.0%	1.9%	2.3%	2.6%	0.0%
14	TVC 14	Edappal	17690	3702	13371	407	1383	289	1740	55	32	28
			45.7%	9.6%	34.6%	1.1%	3.6%	0.7%	4.5%	0.1%	0.1%	0.1%
15	TVC 15	Cheruvannur	22678	3122	11225	123	2356	703	2149	594	229	26
			52.5%	7.2%	26.0%	0.3%	5.5%	1.6%	5.0%	1.4%	0.5%	0.1%

Sl. No.	ID	Location Name	TW	Pass. Auto	Car/ Taxi	Mini Bus	Bus	Goods Auto	LCV	Truck	MAV/ Tractor-Trailer	Others
16	TVC 16	Azhinjillam	19616	2020	22386	331	512	372	4032	1073	1534	103
			37.7%	3.9%	43.1%	0.6%	1.0%	0.7%	7.8%	2.1%	3.0%	0.2%
17	TVC 17	Muzhapilangad Toll Plaza	10011	2463	9592	226	1102	419	2854	1078	1055	37
			34.7%	8.5%	33.3%	0.8%	3.8%	1.5%	9.9%	3.7%	3.7%	0.1%
18	TVC 18	Kanhangad South	8337	2188	9128	152	1099	177	1948	900	1188	48
			33.1%	8.7%	36.3%	0.6%	4.4%	0.7%	7.7%	3.6%	4.7%	0.2%
	Average		42.4%	6.7%	36.3%	0.8%	3.3%	2.3%	4.6%	1.8%	1.8%	0.1%

4.3.5 Peak Hour

The peak hour traffic details (year 2019) observed at all the traffic count survey locations, including their observed peak hour time, its associated traffic and the peak hour factor at the particular location are shown **Table** 4-39. The average peak hour factor was observed to be 6.68% and the observed average peak hour PCU is 2419.

Table 4-39: Peak Hour Traffic Characteristics

Sl.No.	ID	Location	Road Stretch	Peak Hour			Total		Peak Hour Factor
				Time	Vehicles	PCU	Vehicles	PCU	
1	TVC 01	Thottakadu	Thiruvananthapuram-Kollam	17:00-18:00	2,609	2,495	38,673	39,736	6.28%
2	TVC 02	Kilimanoor	Thiruvananthapuram-Kollam	17:00-18:00	2,271	2,133	32,713	32,009	6.66%
3	TVC 03	Karunagapally	Kollam-Chengannur	10:00-11:00	4,512	3,595	61,759	53,716	6.69%
4	TVC 04	Sasthamcotta	Kollam-Chengannur	11:00-12:00	1,835	1,449	22,448	17,957	8.07%
5	TVC 05	Adoor Bypass	Kollam-Chengannur	10:00-11:00	1,238	1,223	18,145	18,478	6.62%
6	TVC 06	Ezhinjillam	Chengannur-Kottayam	17:00-18:00	2,047	1,887	28,473	29,930	6.30%
7	TVC 07	Cherthala	Kottayam-Ernakulam	18:00-19:00	1,670	1,171	20,447	15,641	7.48%
8	TVC 08	Udayamperoor	Kottayam-Ernakulam	08:00-09:00	2,680	2,084	32,801	28,235	7.38%
9	TVC 09	Kumbalam Toll Plaza	Kottayam-Ernakulam	08:00-09:00	4,870	3,898	59,014	59,410	6.56%
10	TVC 10	Kumaranalloor	Kottayam-Ernakulam	10:00-11:00	3,109	3,093	45,229	46,609	6.64%
11	TVC 11	Paliyekkara Toll Plaza	Ernakulam-Thrissur	17:00-18:00	5,368	5,385	77,639	90,382	5.96%
12	TVC 12	Moothakunnam	Ernakulam-Thrissur	17:00-18:00	2,693	2,309	36,764	33,760	6.84%
13	TVC 13	Gurupadapuri	Thrissur-Tirur	16:00-17:00	990	941	13,213	12,751	7.38%

Sl.No.	ID	Location	Road Stretch	Peak Hour			Total		Peak Hour Factor
				Time	Vehicles	PCU	Vehicles	PCU	
14	TVC 14	Edappal	Thrissur-Tirur	09:00-10:00	2,503	2,106	38,352	33,717	6.25%
15	TVC 15	Cheruvannur	Tirur-Kozhikode	17:00-18:00	3,071	2,646	42,827	39,432	6.71%
16	TVC 16	Azhinjillam	Tirur-Kozhikode	17:00-18:00	3,555	3,191	51,484	52,824	6.04%
17	TVC 17	Muzhapilangad Toll Plaza	Kozhikode-Kannur	17:00-18:00	1,971	1,951	28,702	33,465	5.83%
18	TVC 18	Kanhangad South	Kannur-Kasaragod	17:00-18:00	1,927	1,995	25,047	30,313	6.58%
Average					**2,718**	**2,419**	**37,429**	**37,131**	**6.68%**

4.3.6 Directional Split

Directional split observed at all the survey location based on both vehicles and PCU is given in **Table** 4-40. No major variation in directional flow is observed. Maximum variation observed is 47:53 at TVC 02.

Table 4-40: Directional Split (%)

Sl.No.	TVC No.	Location	Direction (Down)	Directional Split-Vehicles(Down: Up)	Directional Split-PCU(Down: Up)
1	TVC 01	Thottakadu	Thiruvananthapuram-Kollam	51:49	50:50
2	TVC 02	Kilimanoor	Thiruvananthapuram-Kollam	47:53	47:53
3	TVC 03	Karunagapally	Kollam-Chengannur	51:49	50:50
4	TVC 04	Sasthamcotta	Kollam-Chengannur	51:49	50:50
5	TVC 05	Adoor Bypass	Kollam-Chengannur	52:48	51:49
6	TVC 06	Ezhinjillam	Chengannur-Kottayam	51:49	51:49
7	TVC 07	Cherthala	Kottayam-Ernakulam	51:49	50:50
8	TVC 08	Udayamperoor	Kottayam-Ernakulam	52:48	52:48
9	TVC 09	Kumbalam Toll Plaza	Kottayam-Ernakulam	50:50	49:51
10	TVC 10	Kumaranalloor	Kottayam-Ernakulam	51:49	51:49

Sl.No.	TVC No.	Location	Direction (Down)	Directional Split-Vehicles(Down: Up)	Directional Split-PCU(Down: Up)
11	TVC 11	Paliyekkara Toll Plaza	Ernakulam-Thrissur	50:50	50:50
12	TVC 12	Moothakunnam	Ernakulam-Thrissur	51:49	51:49
13	TVC 13	Gurupadapuri	Thrissur-Tirur	49:51	48:52
14	TVC 14	Edappal	Thrissur-Tirur	49:51	48:52
15	TVC 15	Cheruvannur	Tirur-Kozhikode	50:50	50:50
16	TVC 16	Azhinjillam	Tirur-Kozhikode	50:50	50:50
17	TVC 17	Muzhapilangad Toll Plaza	Kozhikode-Kannur	50:50	50:50
18	TVC 18	Kanhangad South	Kannur-Kasaragod	49:51	49:51

4.3.7 Hourly Variation

Hourly variation of traffic is also analysed from the survey data. **Figure** 4-27 to **Figure** 4-31 show hourly variation in terms of total vehicles and PCUs at some of the important survey locations.

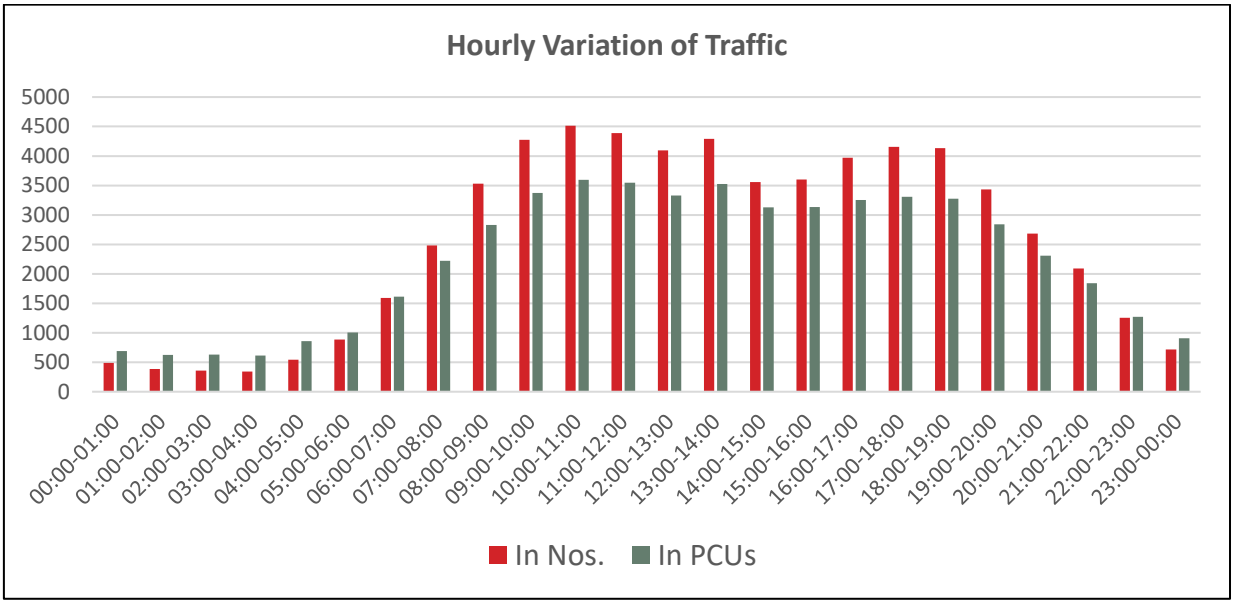


Figure 4-27 Hourly Traffic Variation at Karunagapally

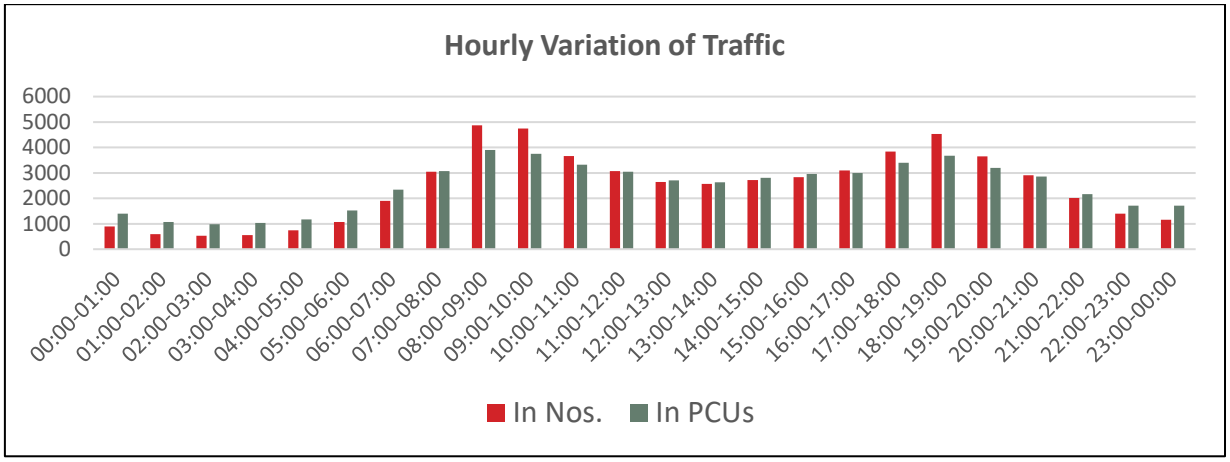


Figure 4-28 Hourly Traffic Variation at Kumbalam

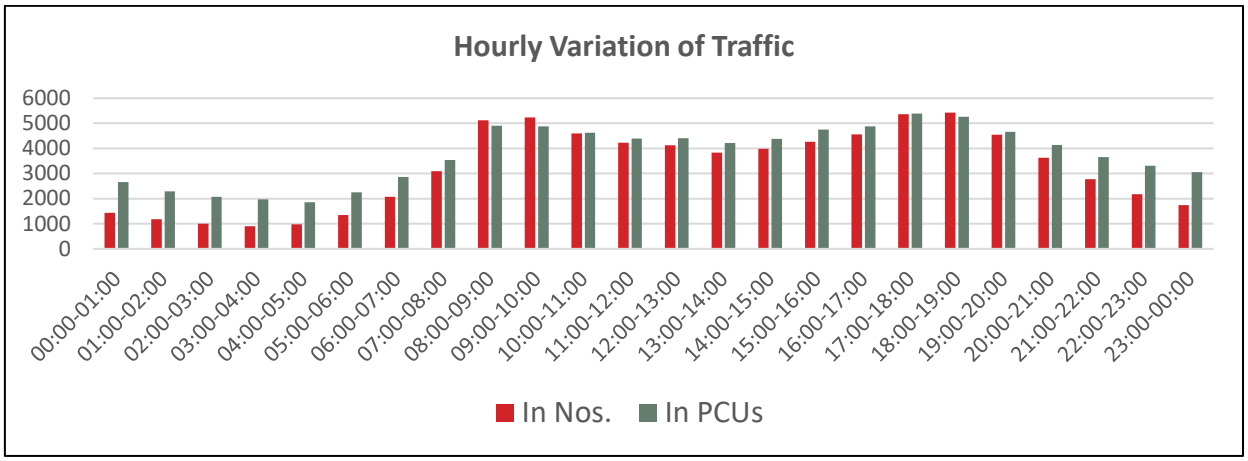


Figure 4-29 Hourly Traffic Variation at Paliyekkara

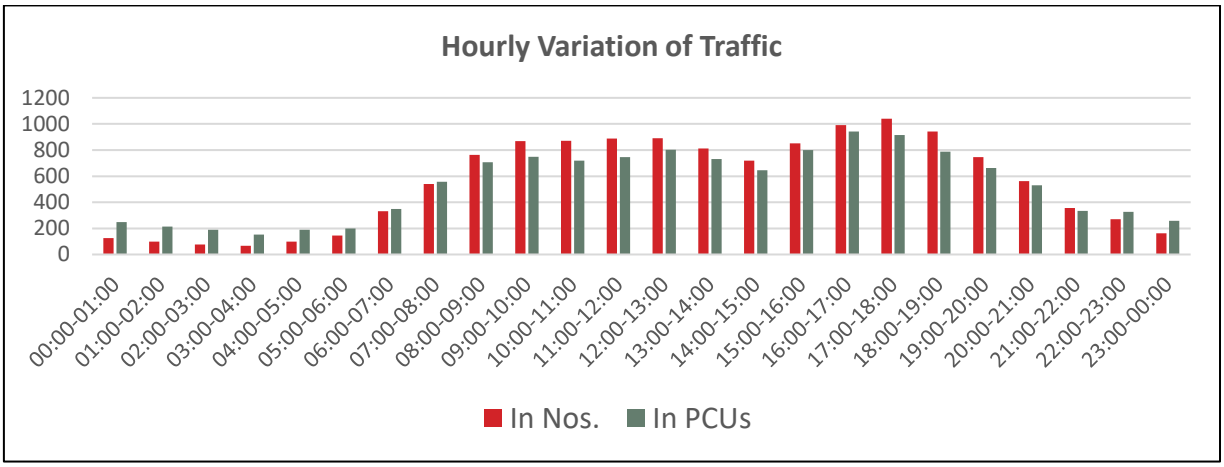


Figure 4-30 Hourly Traffic Variation at Gurupadapuri

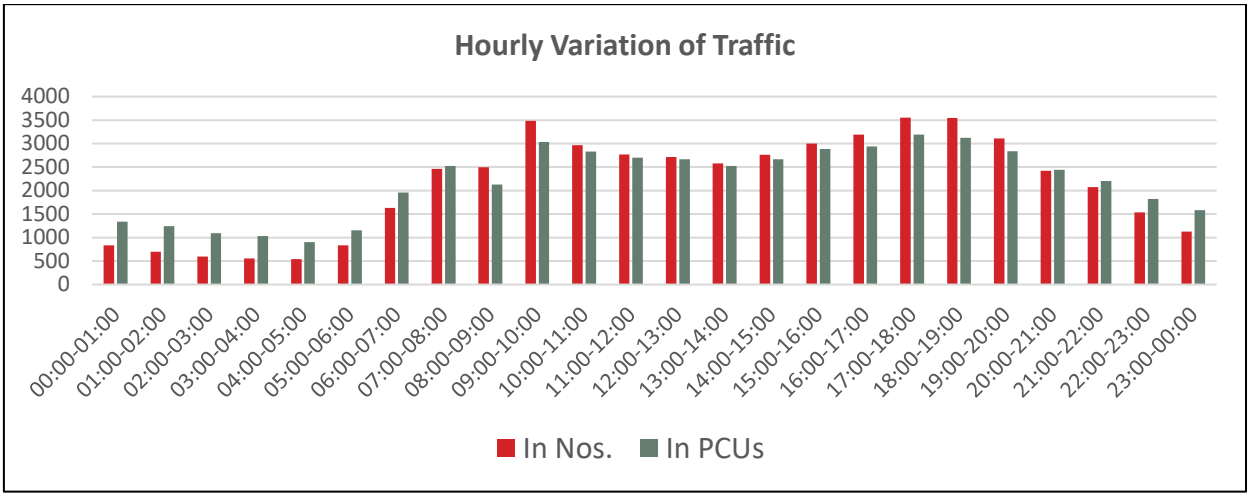


Figure 4-31 Hourly Traffic Variation at Azhinjillam

It can be observed that traffic volume is higher from 8 am to 8 pm and lower at other hours of the day at all locations.

4.3.8 Daily Variation of Traffic

Daily variation of traffic was analyses from the survey data. The daily variation of passenger and goods traffic in terms of total vehicles and PCUs at some of the important survey locations is provided in Volume III – Part 3A Annexure VI. From the data, no general trend in passenger traffic volumes on week and weekend were observed, and not much variation were observed between weekend and week day traffic. But in case of goods traffic weekend traffic was found to be less than week day traffic. There is distinguishable variation between week and weekday goods traffic.

Maximum variation in inter-day traffic at various location is given in **Table** 4-41**.**

Table 4-41: Maximum Inter-day Traffic Variation (%)

Sl. No.	Location ID	Location	Maximum variation in inter-day traffic (%)	
			Vehicles	PCU
1	TVC 01	Thottakadu	4.96	5.67
2	TVC 02	Kilimanoor	1.61	1.40
3	TVC 03	Karunagapally	9.86	8.51
4	TVC 04	Sasthamcotta	7.27	6.69
5	TVC 05	Adoor Bypass	4.11	3.79
6	TVC 06	Ezhinjillam	5.32	5.75
7	TVC 07	Cherthala	8.36	5.16
8	TVC 08	Udayamperoor	4.67	5.86

Sl. No.	Location ID	Location	Maximum variation in inter-day traffic (%)	
			Vehicles	PCU
9	TVC 09	Kumbalam Toll Plaza	3.16	3.36
10	TVC 10	Kumaranalloor	8.10	8.29
11	TVC 11	Paliyekkara Toll Plaza	5.00	2.25
12	TVC 12	Moothakunnam	9.54	8.32
13	TVC 13	Gurupadapuri	9.49	10.24
14	TVC 14	Edappal	2.46	3.45
15	TVC 15	Cheruvannur	10.75	9.83
16	TVC 16	Azhinjillam	7.26	8.70
17	TVC 17	Muzhapilangad Toll Plaza	3.78	4.39
18	TVC 18	Kanhangad South	3.93	2.10

Maximum variation in inter-day traffic was observed at TVC 15, Cheruvannur (10.75% for Vehicles and 9.83% for PCUs)

4.3.9 Vehicle Occupancy Survey

The average occupancy observed for various modes, Car, Taxi, Mini Bus and KSRTC Bus, Private Bus was 2.27, 2.5, 13.82, 28.58 and 29.13 respectively. The average mode-wise occupancy observed at the traffic count locations is shown in **Table** 4-42.

Table 4-42: Average Occupancy at Traffic Count Locations

Location	Car/ Jeep/ Van	Taxi	Autorickshaw	2 - Wheeler	Mini Bus	KSRTC Bus	Private Bus	School Bus
TVC 01	2.60	2.78	2.35	1.42	13.17	25.20	21.96	16.68
TVC 02	2.35	2.72	2.42	1.46	14.21	41.38	37.45	18.94
TVC 03	2.02	2.21	2.04	1.44	11.32	28.35	21.54	16.74
TVC 04	1.74	2.17	2.39	1.35	12.34	26.83	26.56	18.17
TVC 05	2.02	2.27	1.99	1.27	9.32	14.50	24.32	12.97
TVC 06	2.32	2.91	2.28	1.42	14.50	30.71	35.25	23.24
TVC 07	2.11	2.32	2.22	1.39	12.45	31.45	27.93	18.67

Location	Car/ Jeep/ Van	Taxi	Autorickshaw	2 - Wheeler	Mini Bus	KSRTC Bus	Private Bus	School Bus
TVC 08	2.29	2.51	2.60	1.56	13.85	25.43	25.30	13.13
TVC 09	2.48	3.02	2.45	1.42	16.16	34.72	35.38	18.34
TVC 10	2.22	2.63	2.00	1.41	14.35	22.59	27.67	22.37
TVC 11	2.28	2.51	2.44	1.38	12.67	25.86	27.23	17.90
TVC 12	2.29	3.00	2.31	1.45	21.11	36.75	36.40	27.72
TVC 13	2.29	2.27	2.13	1.39	11.54	28.05	32.67	13.80
TVC 14	2.23	2.05	1.97	1.67	16.45	28.05	28.13	23.58
TVC 15	2.68	2.36	2.19	1.38	13.44	30.33	32.45	15.83
TVC 16	2.56	2.82	2.48	1.49	16.63	32.86	29.46	15.38
TVC 17	2.40	2.23	2.20	1.38	15.38	28.22	29.25	22.99
TVC 18	1.97	2.21	2.01	1.33	9.86	23.23	25.32	12.04
Average	**2.27**	**2.50**	**2.25**	**1.42**	**13.82**	**28.58**	**29.13**	**18.25**

Based on vehicle occupancy data and traffic volume count, total daily passenger trips at each location are calculated as given in **Table** 4-43**.** The total passengers include only those travelling by Car, Taxi and Bus.

Table 4-43: Daily Passenger Trips (Car, Taxi and Bus)

TVC No.	Location	Passenger Trips - Car, Taxi & Bus	Ranking
TVC 01	Thottakadu	255757	5
TVC 02	Kilimanoor	249837	6
TVC 03	Karunagapally	235198	7
TVC 04	Sasthamcotta	83927	15
TVC 05	Adoor Bypass	67973	16
TVC 06	Ezhinjillam	204196	9
TVC 07	Cherthala	59092	17
TVC 08	Udayamperoor	151602	13

TVC No.	Location	Passenger Trips - Car, Taxi & Bus	Ranking
TVC 09	Kumbalam Toll Plaza	284511	4
TVC 10	Kumaranalloor	320296	2
TVC 11	Paliyekkara Toll Plaza	423308	1
TVC 12	Moothakunnam	196679	10
TVC 13	Gurupadapuri	48803	18
TVC 14	Edappal	196139	11
TVC 15	Cheruvannur	305776	3
TVC 16	Azhinjillam	211713	8
TVC 17	Muzhapilangad Toll Plaza	155156	12
TVC 18	Kanhangad South	129041	14

4.4 DATA ANALYSIS – TRAVEL CHARACTERISTICS

4.4.1 Origin and Destination (OD) Survey

OD survey was conducted at 9 identified locations, where the Classified Traffic Volume Surveys were conducted. The study area has been divided into 197 Traffic Analysis Zones (TAZ). The list of Zones and numbers are provided in Volume III – Part 3A, Annexure III.

Based on the Origin Destination Survey, separate mode wise OD matrices for car and taxi are developed. Both car and taxi passengers have been considered as potential users for SilverLine.

OD matrix for Car and Taxi were formulated by combining data at all the OD survey locations. While combining the data, due consideration was given in avoiding duplication of vehicles. Vehicles which have already passed another OD survey location earlier during its trip were discarded while combining data.

4.4.1.1 OD Sample Size

OD samples size for various vehicle categories at all the survey location is given in **Table** 4-44**.**

Table 4-44: OD Sample Size (%)

TVC No.	Location	Car	Taxi	Mini Bus	Bus	LCV	Truck	MAV	Total Passenger	Total Goods	Total Vehicles
TVC 01	Thottakadu	29.6	53.6	10.5	24.9	32.3	64.6	38.9	30.1	38.8	31.5
TVC 03	Karunagapally	19.0	40.4	43.0	60.6	27.5	45.7	43.2	23.0	32.6	24.9
TVC 06	Ezhinjillam	26.5	66.8	35.4	36.1	16.4	36.5	49.6	29.2	25.1	28.3
TVC 09	Kumbalam Toll Plaza	23.5	58.8	7.6	44.6	27.4	40.1	27.9	27.0	29.8	27.9
TVC 11	Paliyekkara Toll Plaza	21.2	35.9	31.2	21.4	15.4	60.2	16.3	22.4	22.3	22.4
TVC 13	Gurupadapuri	27.0	33.7	12.9	46.8	35.8	40.7	40.1	28.9	37.8	31.9
TVC 16	Azhinjillam	29.9	56.1	40.1	78.1	24.3	40.9	33.4	32.2	28.6	31.3
TVC 17	Muzhapilangad Toll Plaza	26.5	35.1	33.0	90.4	39.6	66.2	38.7	33.1	44.4	36.9
TVC 18	Kanhangad South	48.6	44.1	27.3	76.3	62.2	72.6	47.5	50.9	60.4	53.7

4.4.2 Trip Characteristics- Car/Taxi Trip

This section discusses trip length, trip purpose and trip frequency distribution of car/taxi passengers. Trip length distribution of Car/ Taxi trips is shown in the **Figure** 4-32**.**

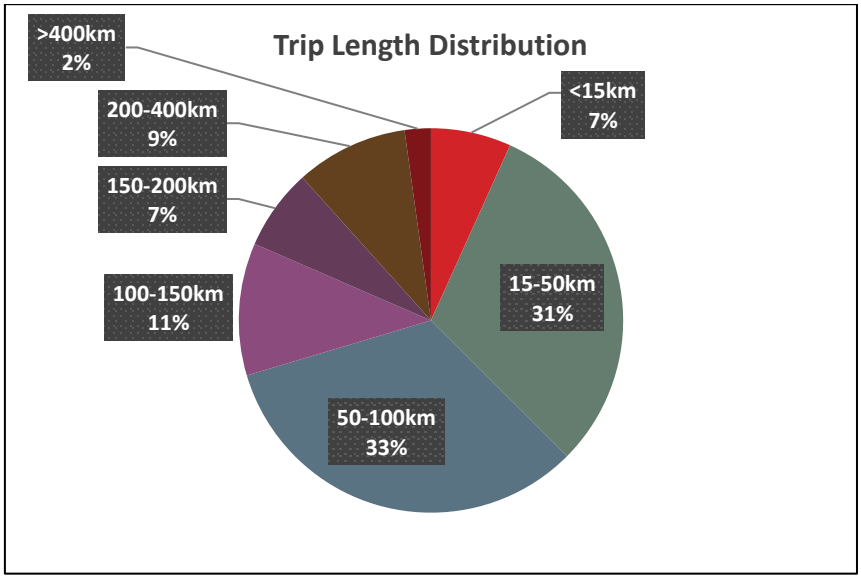


Figure 4-32 Trip Length Distribution- Car/ Taxi Trips

Trips less than 50 km consists of 38% and 50- 150 km trips constitute 44% of total trips. Trip characteristics and their attributes are considered to vary across trip purposes, hence understanding the nature of trip purpose is important for demand assessment. The trip purposes have been broadly categorized into four major trip purposes, viz. Work Business, Education, Social, Tourist and Other trips. The respective share of each category, as obtained from Road side OD Survey is shown in **Figure** 4-33**.**

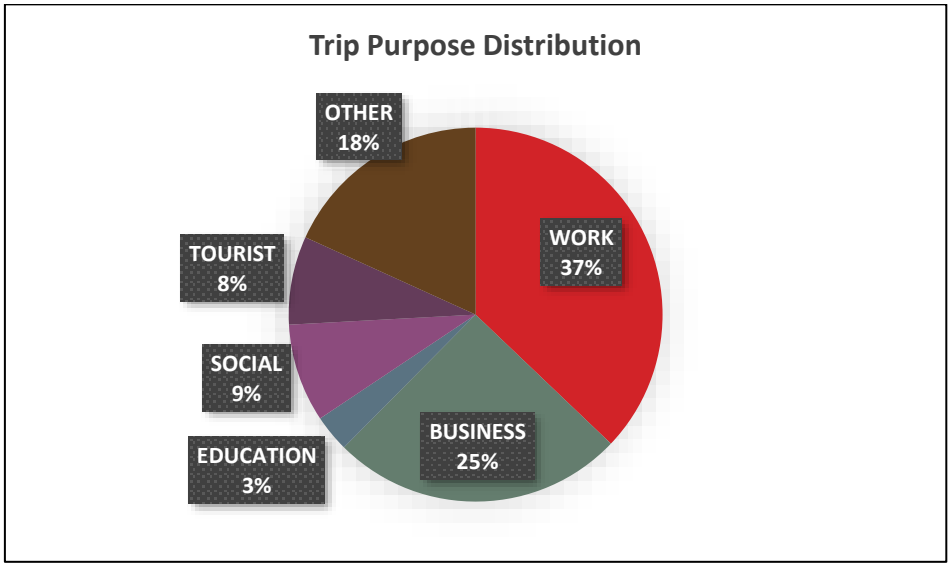


Figure 4-33 Trip Purpose Distribution- Car/ Taxi Trips

Maximum trips were seen to be performed under the categories of Work and Business Trips. While the least recorded share as observed from the Road-side OD survey was for Education. Tourist trips form 8% of the total.

Trip frequency is also a descriptive characteristic which aids in analysing the nature of trips that occurs within the study corridor. The trip frequency has been captured as daily,

weekly, monthly or occasionally. The respective share of each category, as obtained from Road side OD Survey, is shown in **Figure** 4-34.

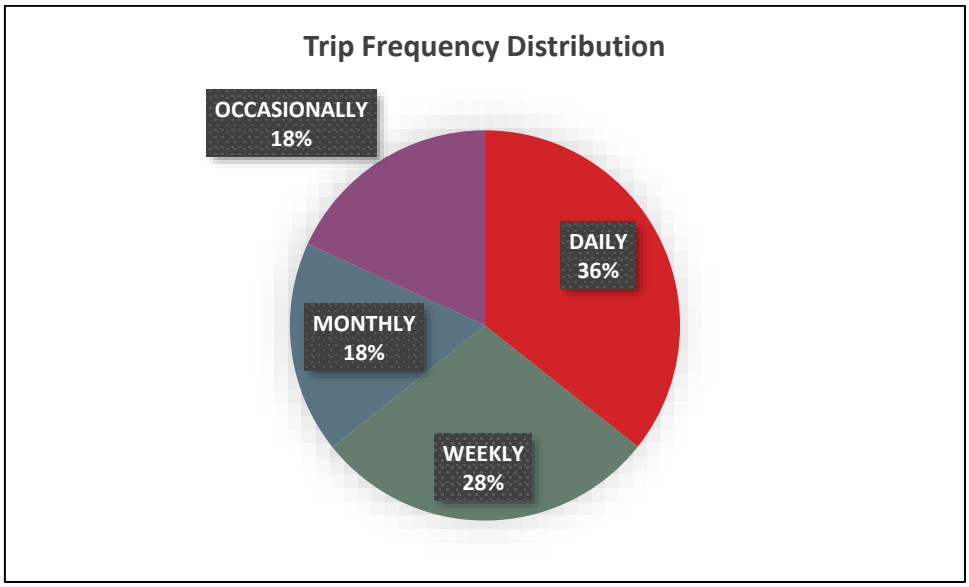


Figure 4-34 Trip Frequency Distribution- Car/ Taxi Trips

It can be seen that the majority of the trips are Daily or Weekly (36 % and 28% respectively).

4.4.3 Trip Characteristics - Goods Traffic

Analysis of goods traffic along project corridor provides insight into the type of commodity being transported, trip length and trip frequency of the candidate traffic. **Figure** 4-35 shows trip length distribution of goods traffic observed during the OD Survey.

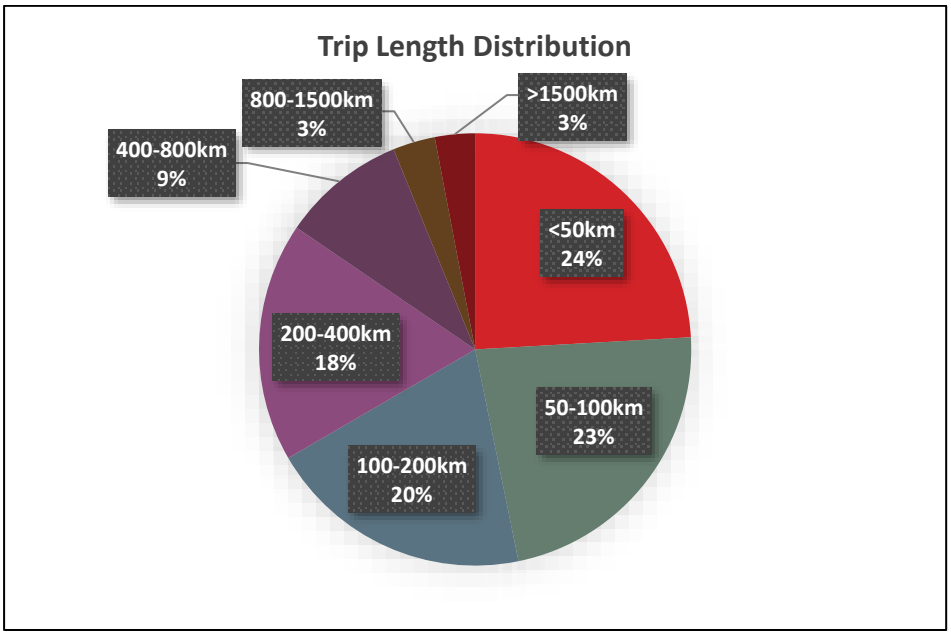


Figure 4-35 Trip Length Distribution- Goods Vehicles

Trips less than 100 km consists of 47% and more than 100 km trips constitute 53% of total trips. Type of commodity being transported along project corridor is important in deciding possible diversion to proposed RORO system. 14 different categories of commodities are considered in the analysis. **Figure** 4-36 shows commodity distribution of goods traffic.

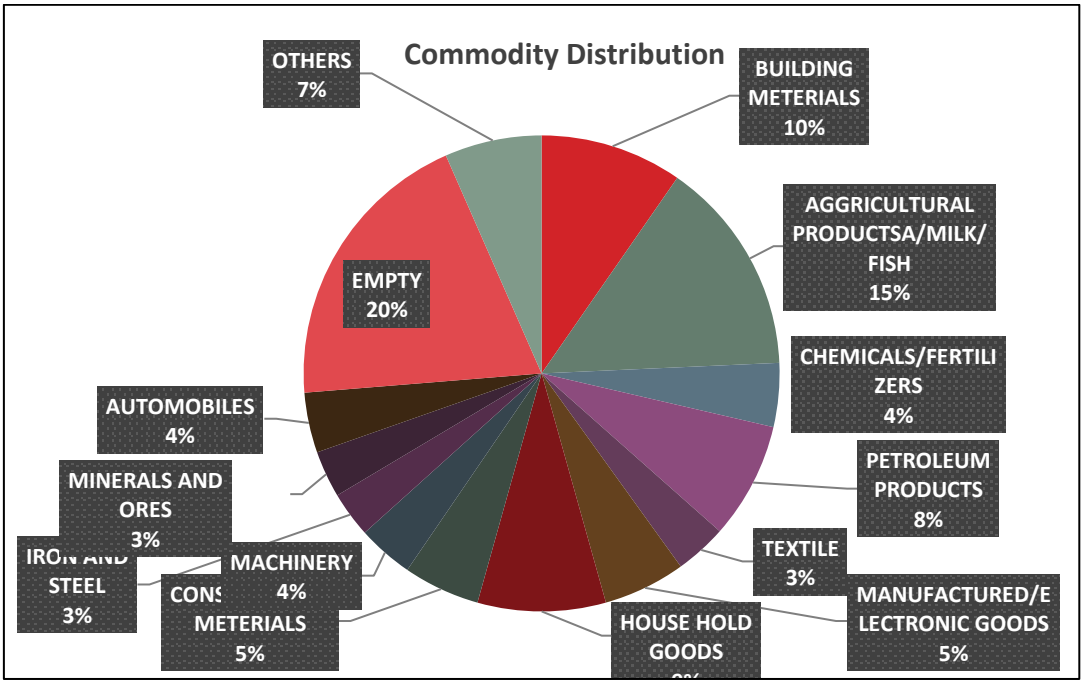


Figure 4-36 Trip Purpose Distribution- Goods Vehicles

20% of the trucks are travelling empty. Major goods being transported are Agricultural products/Milk/ Fish, Building materials, Household goods, and petroleum products.

Analysis trip frequency aids in analysing the nature of trips that occurs within the study corridor. The trip frequency has been captured as daily, weekly, monthly or occasionally. The respective share of each category, as obtained from OD Survey, is shown in **Figure** 4-37.

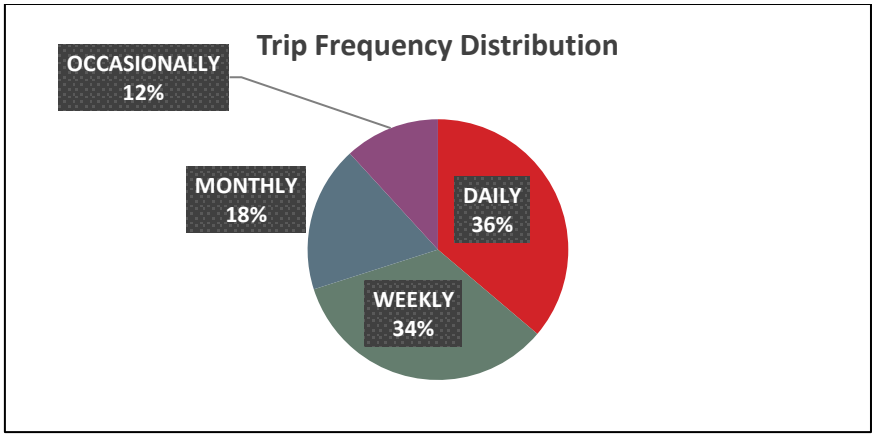


Figure 4-37 Trip Frequency Distribution- Goods Vehicles

It can be seen that the majority of the trips are Daily or Weekly (36 % and 34% respectively).

4.4.4 Trip Contribution

Contribution of trips on the project corridors, from Kerala and neighbouring States, gives proper insight in forecasting of trips. Table below shows the contribution of passenger and goods trips from Kerala and neighbouring States.

Table 4-45: Trip Contribution- Passenger Trips (%)

Category/ State	Kerala	Tamil Nadu	Karnataka	Puducherry	Rest of India
AC BUS-KSRTC	98.3%	0.8%	0.7%	0.1%	0.0%
AC LOW FLOOR BUS-KSRTC	96.1%	2.5%	0.7%	0.4%	0.3%
AC BUS-PVT.	93.5%	5.0%	0.4%	0.0%	1.0%
CAR/JEEP/VAN	97.2%	1.5%	0.4%	0.6%	0.3%
DELUXE BUS	87.4%	3.2%	8.0%	0.1%	1.3%
EXPRESS BUS	98.3%	1.5%	0.0%	0.0%	0.2%
FAST PASSENGER BUS	95.7%	3.6%	0.0%	0.6%	0.1%
MINI BUS	97.1%	1.7%	0.7%	0.3%	0.2%
ORDINARY BUS	98.1%	1.1%	0.3%	0.3%	0.0%
SUPER FAST BUS	97.6%	2.2%	0.0%	0.2%	0.0%
TAXI	96.4%	2.3%	0.4%	0.5%	0.4%

Majority of the passenger trips are within Kerala. In Deluxe Buses category, contribution of Other States is higher compared to other categories.

Table 4-46: Trip Contribution- Goods Trips (%)

Category/ State	Kerala	Tamil Nadu	Karnataka	Puducherry	Rest of India
TEMPO	98.1%	0.9%	0.3%	0.4%	0.4%
LCV	92.0%	4.5%	1.2%	1.0%	1.3%
2-3 AXLE TRUCK	85.1%	7.1%	4.1%	0.9%	2.7%
MULTI AXLE TRUCK	77.1%	7.1%	5.7%	2.2%	8.0%

Along the PIA, in goods vehicles, majority of the trips is within Kerala. Second major contribution is from Tamil Nadu followed by Karnataka.

Major OD pairs identified for Goods trips are:

- Thrissur City- Ernakulam (5.29%)
- Ernakulam- Thiruvananthapuram City(2.76%)
- Kochi- Kollam City (2.53%)
- Kollam City- Thiruvananthapuram City (2.17%)
- Rest of India- Kochi (1.91%)
- Kannur city – Kozhikode City (1.88%)

4.4.5 Passenger Terminal OD Survey at Identified Airport, Bus and Train Terminals

The interview of passengers at identified terminals (4 Airports, 4 Bus Terminals and 4 Train Terminals) were conducted to establish existing travel pattern of commuters. This section describes characteristics of the data collected at Airport, Bus and Rail Terminals separately.

4.4.5.1 Airports

Survey of passengers was conducted at Thiruvananthapuram, Kochi, Kannur and Calicut International airports. This section combines data at all the airports and provides details of general characteristics as observed (**Figure** 4-38 to **Figure** 4-45**)**.

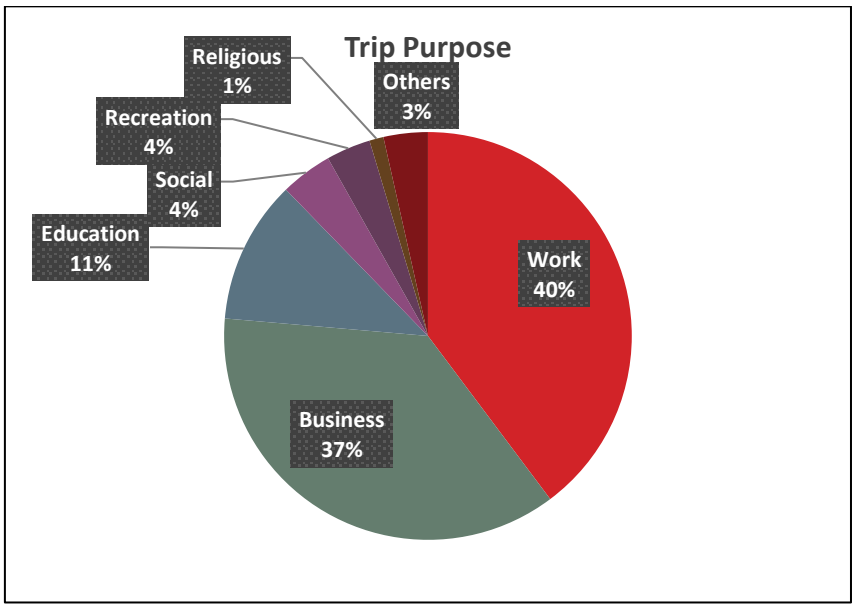


Figure 4-38 Trip Purpose Distribution- Airport

Majority of the trips are work trips followed by Business trips (together constituting 77%). Recreational trips are only 4%.

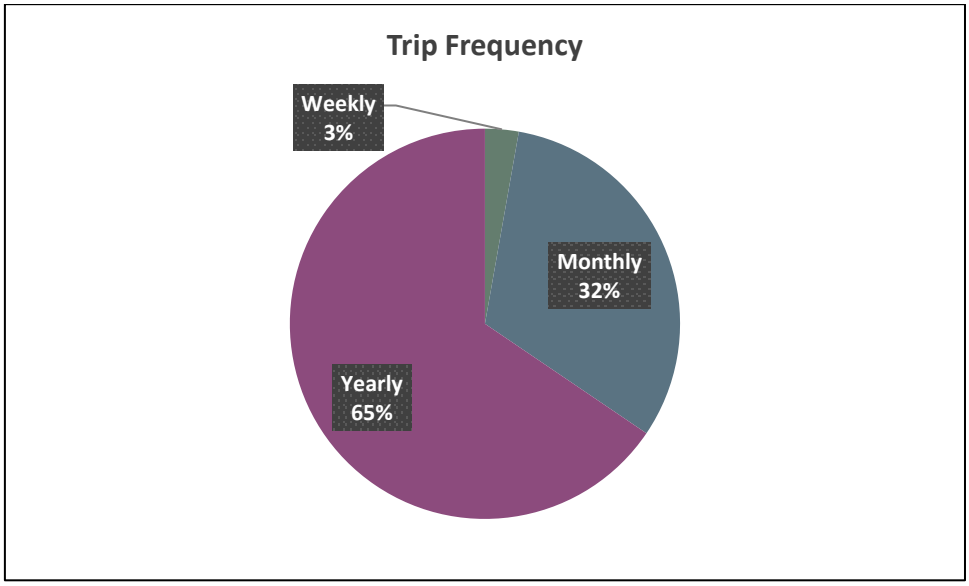


Figure 4-39 Trip Frequency Distribution- Airport

Majority of the trips are of yearly trips (65%). Monthly trips constitute 32% and weekly trips are only 3%.

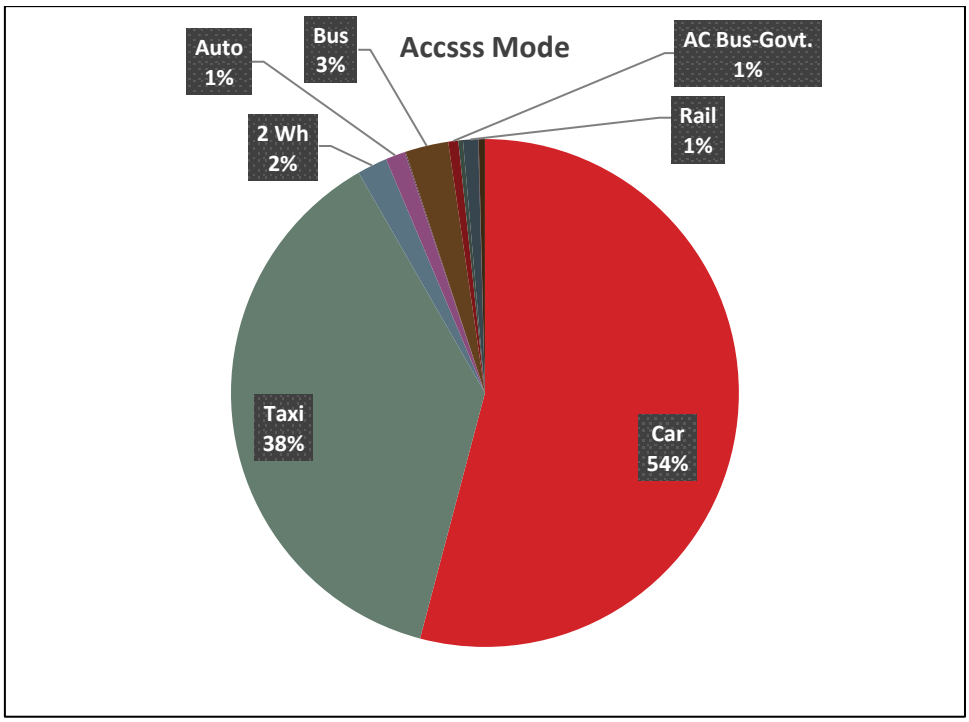


Figure 4-40 Access Mode - Airport

Car is the major mode of access to Airport (54%) followed by Taxi (38%).

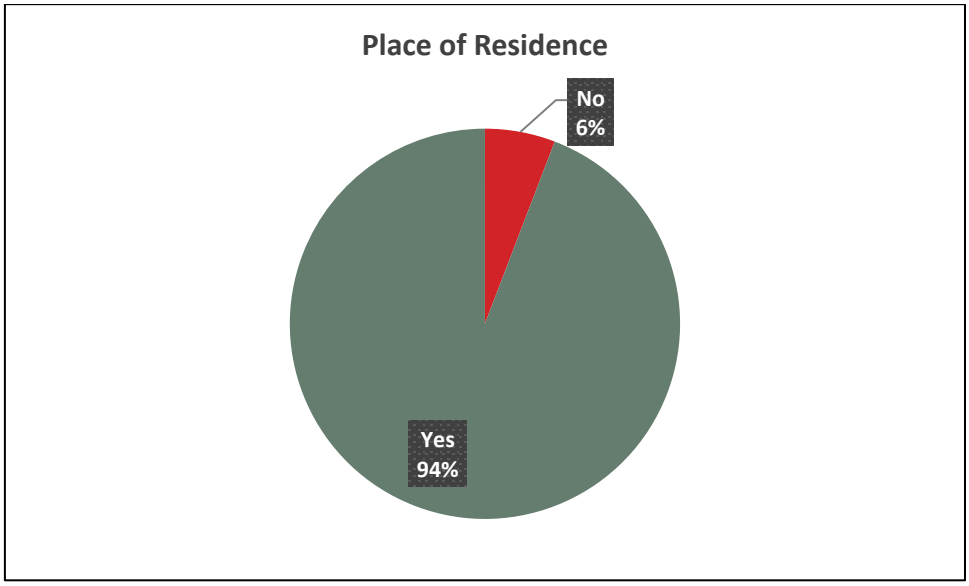


Figure 4-41 Place of Residence - Airport

Majority of the respondents are Keralites (94%).

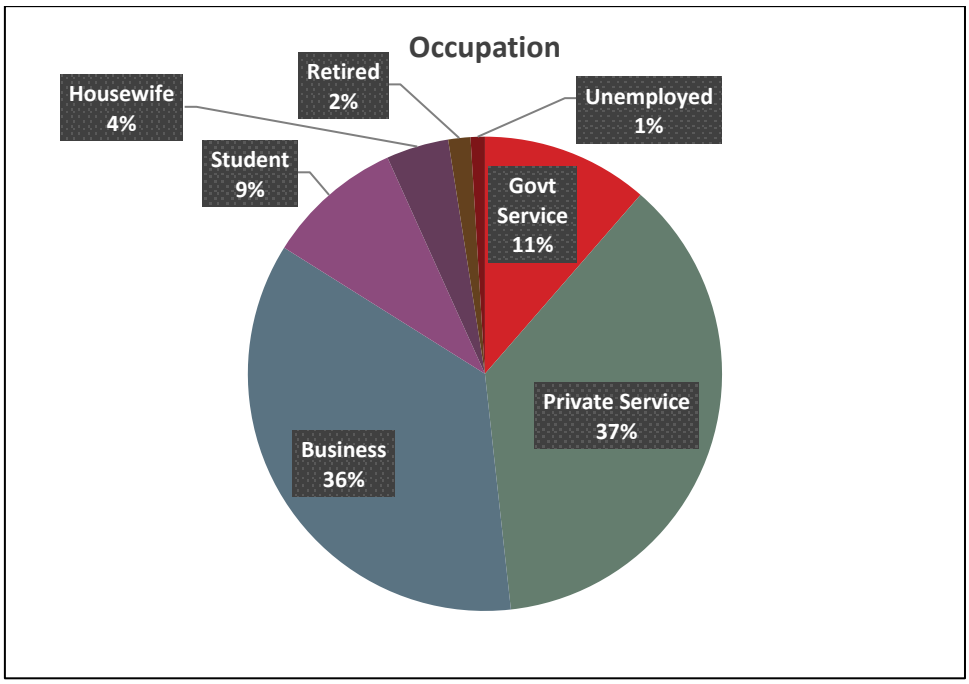


Figure 4-42 Occupation Distribution- Airport

Occupation of majority of the respondents is Private Service and Business (37% and 36% respectively).

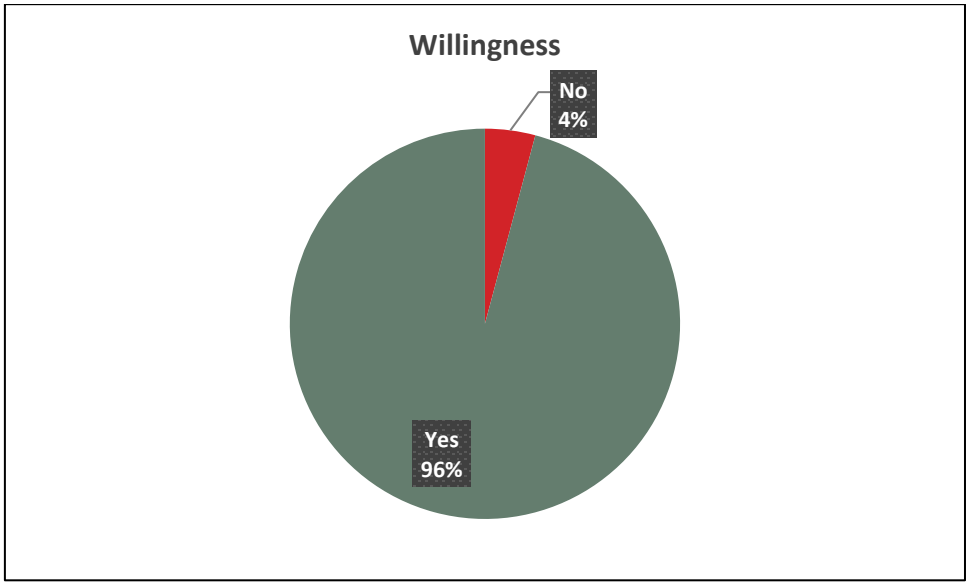


Figure 4-43 Willingness To Shift- Airport

96% of the total respondents showed willingness to shift to SilverLine.

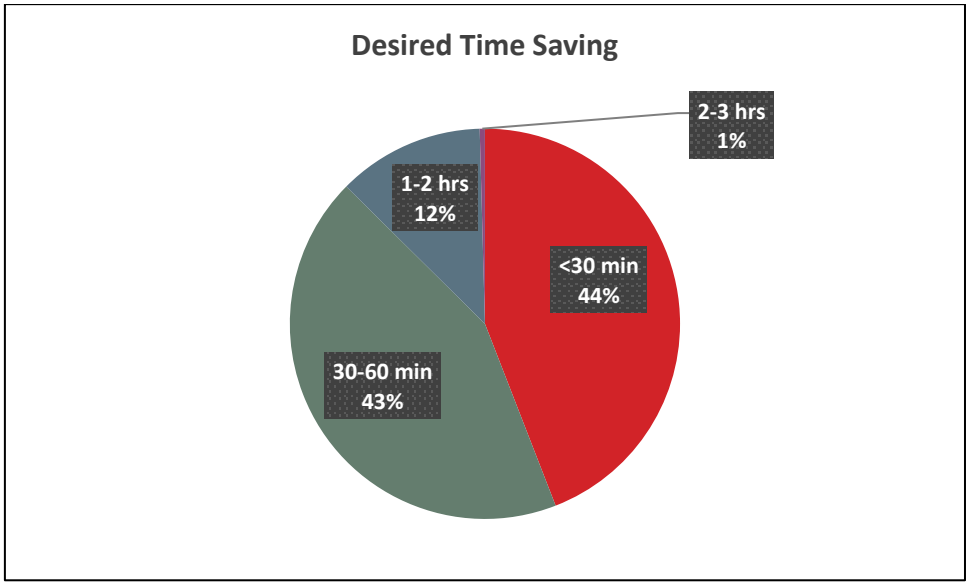


Figure 4-44 Desired Time Saving- Airport

Desired time saving for majority of the respondents was less than 30 minutes and 30-60 minutes (44% and 43% respectively).

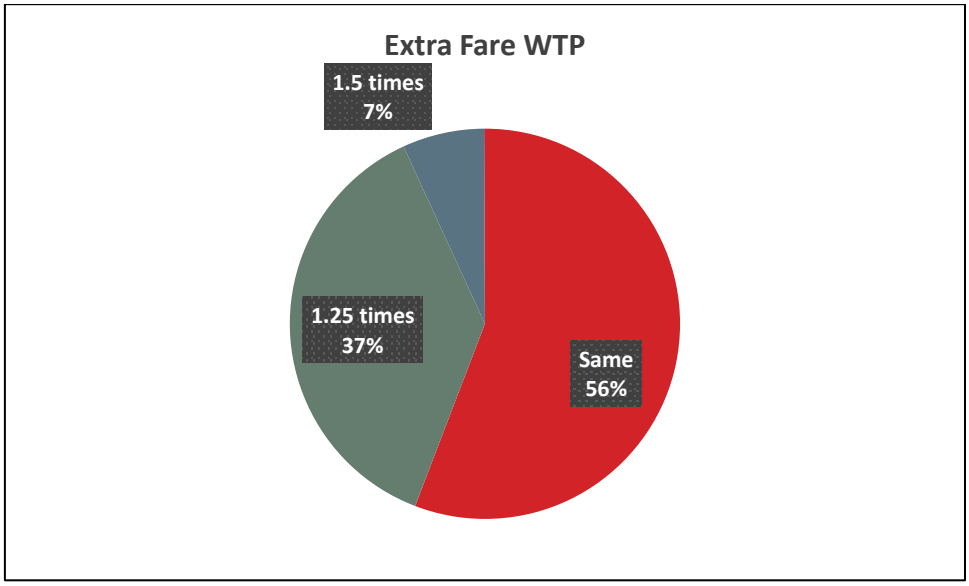


Figure 4-45 Extra Fare Willing To Pay - Airport

Most of the respondents were only willing to pay same fare (56%). 37% and 7% expressed willingness to pay 1.25 and 1.5 times respectively.

4.4.5.2 Bus Terminal

Survey was conducted at Thiruvananthapuram KSRTC Bus Station, Ernakulam – Vytila Bus Terminal, Thrissur KSRTC Bus Terminal and Kozhikode Private Bus Terminal. Data at all the locations are combined and general characteristics of passengers at Bus are given in **Figure** 4-46 to **Figure** 4-53**.**

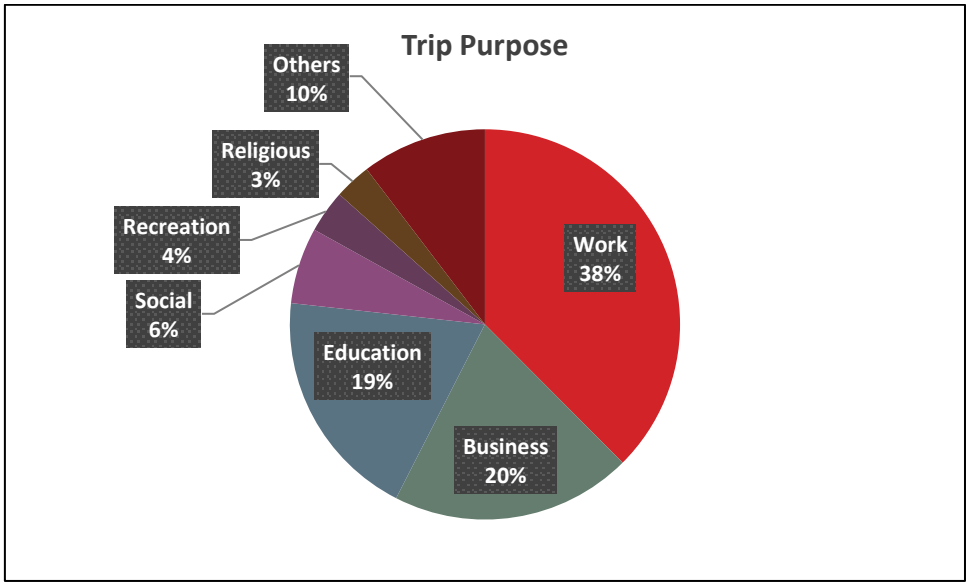


Figure 4-46 Trip Purpose Distribution- Bus Terminal

Majority of the trips are work trips followed by Business Trips (together constituting 58%). Recreational trips are only 4%.

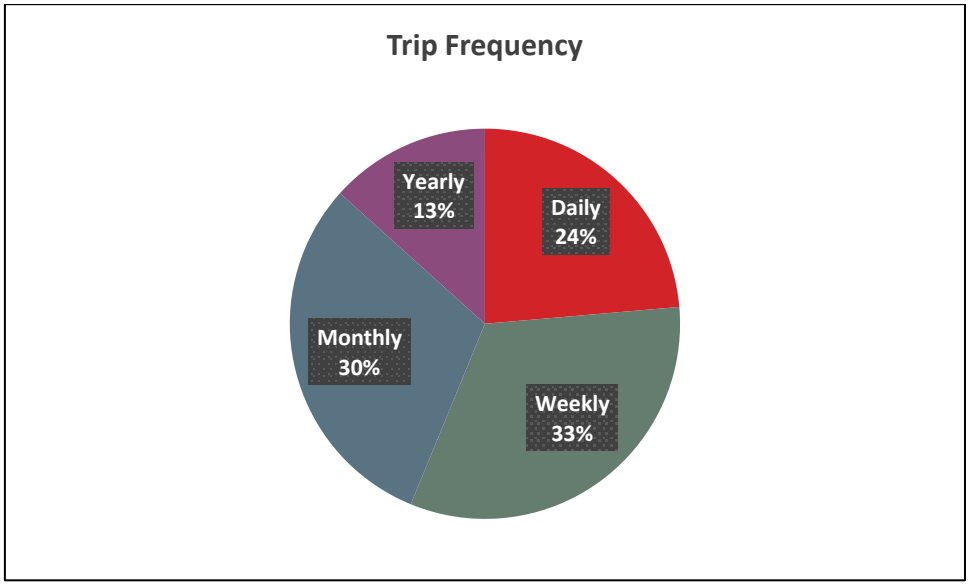


Figure 4-47 Trip Frequency Distribution- Bus Terminal

Majority of the trips are of Weekly trips (33%). Monthly trips constitute 30% and daily trips are 24%.

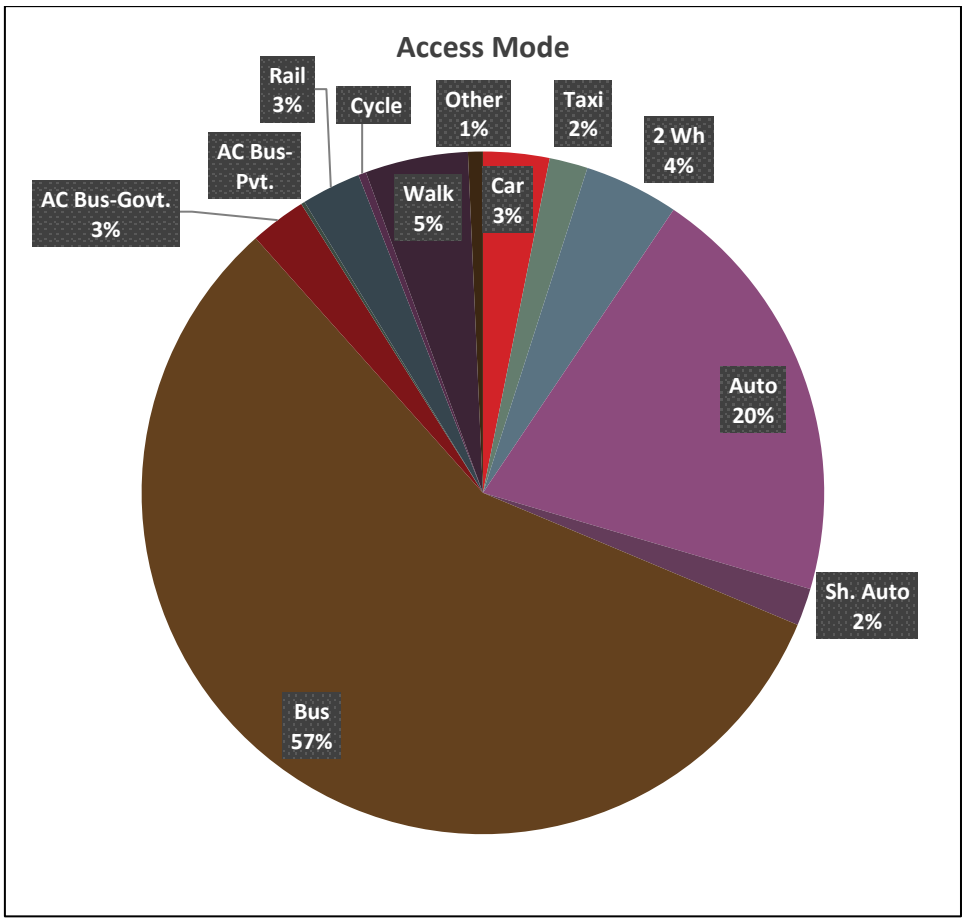


Figure 4-48 Access Mode - Bus Terminal

Ordinary Bus is the major mode of access mode to Bus Terminal (57%) followed by Auto Rickshaw (20%).

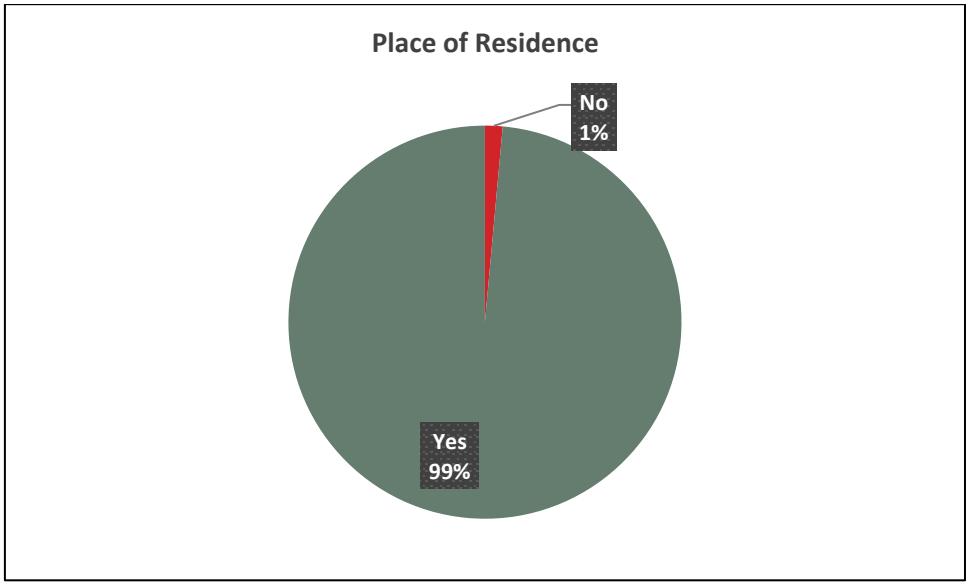


Figure 4-49 Place of Residence - Bus Terminal

Majority of the commuters are Keralites (99%).

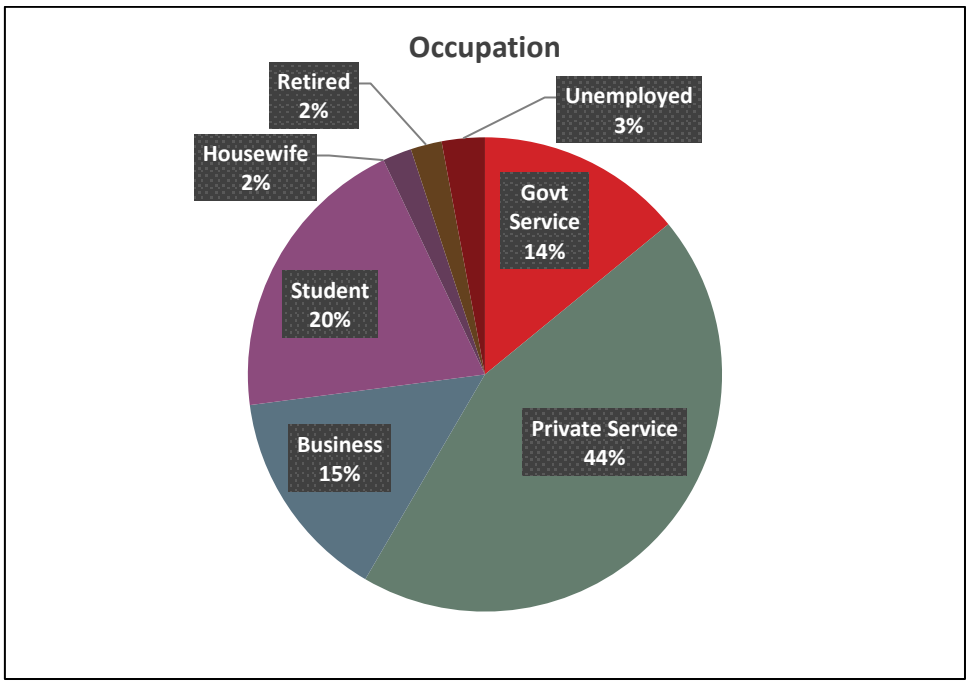


Figure 4-50 Occupation Distribution- Bus Terminal

Occupation of majority of the Bus passengers are private services (44%).

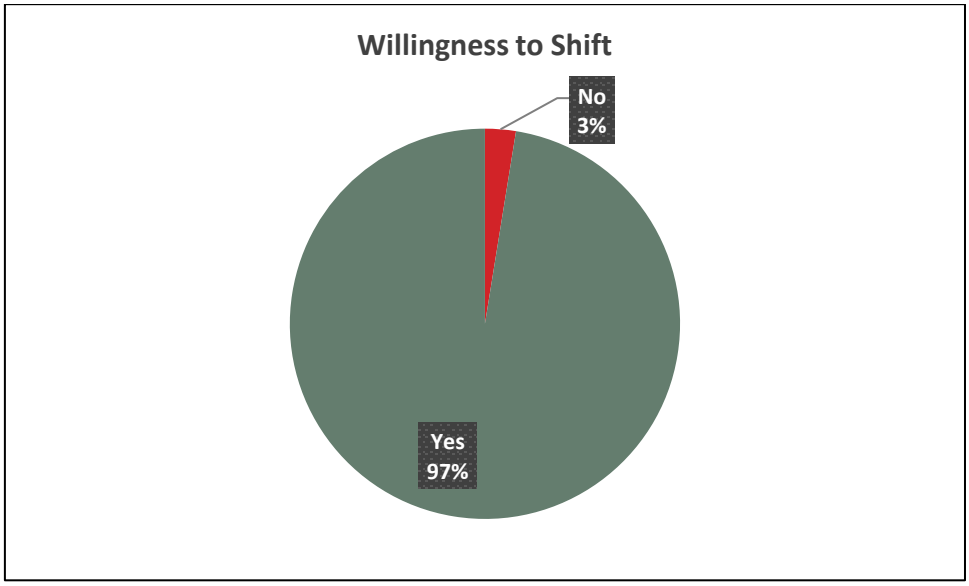


Figure 4-51 Willingness to Shift- Bus Terminal

97% of the total commuters showed willingness to shift to SilverLine.

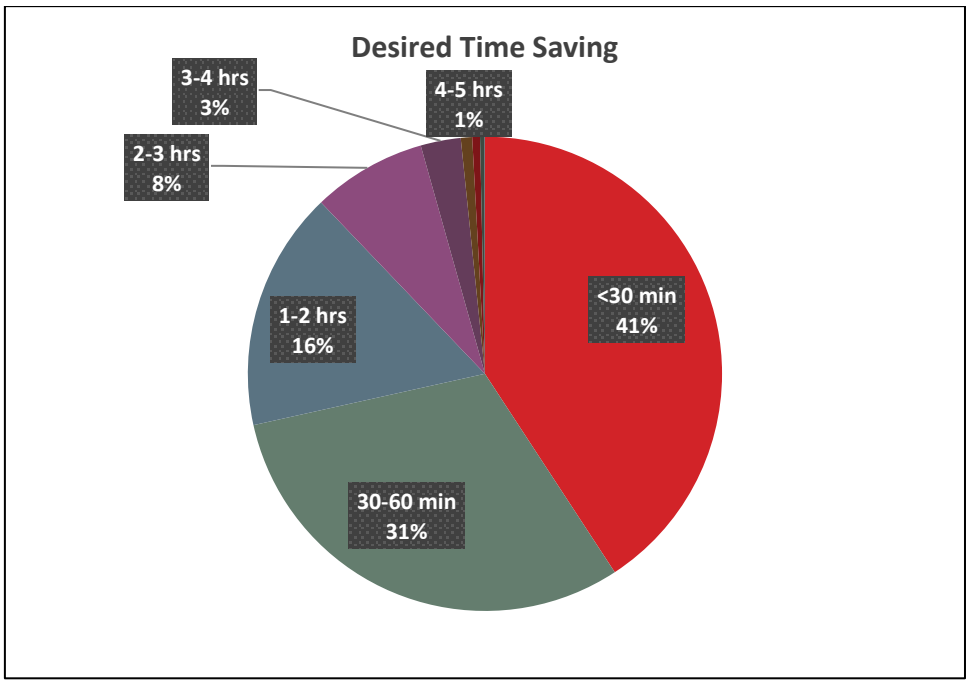


Figure 4-52 Desired Time Saving- Bus Terminal

Desired time saving for majority of the commuters is less than 30 minutes and 30-60 minutes (41% and 31% respectively).

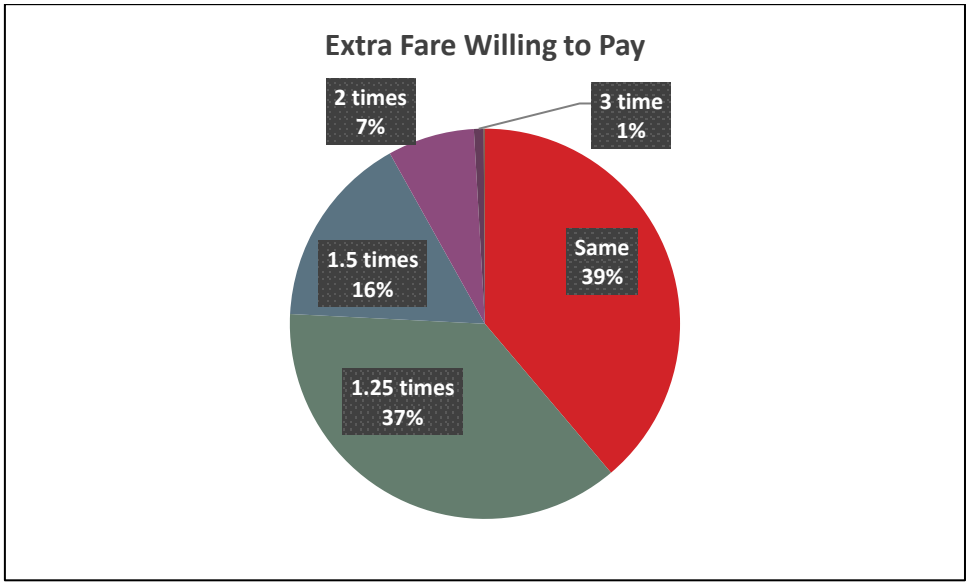


Figure 4-53 Extra Fare Willing To Pay- Bus Terminal

Most of the commuters are only willing to pay same fare as their existing mode (39%). 39% and 16% of respondents expressed willingness to pay 1.25 and 1.5 times of the fare respectively.

4.4.5.3 Railway Terminals

Survey of rail passengers was conducted at Thiruvananthapuram, Kollam, Ernakulam South and Kozhikode railway stations. Data of all the 4 locations are combined and general characteristics as observed are given in **Figure** 4-54 to **Figure** 4-61.

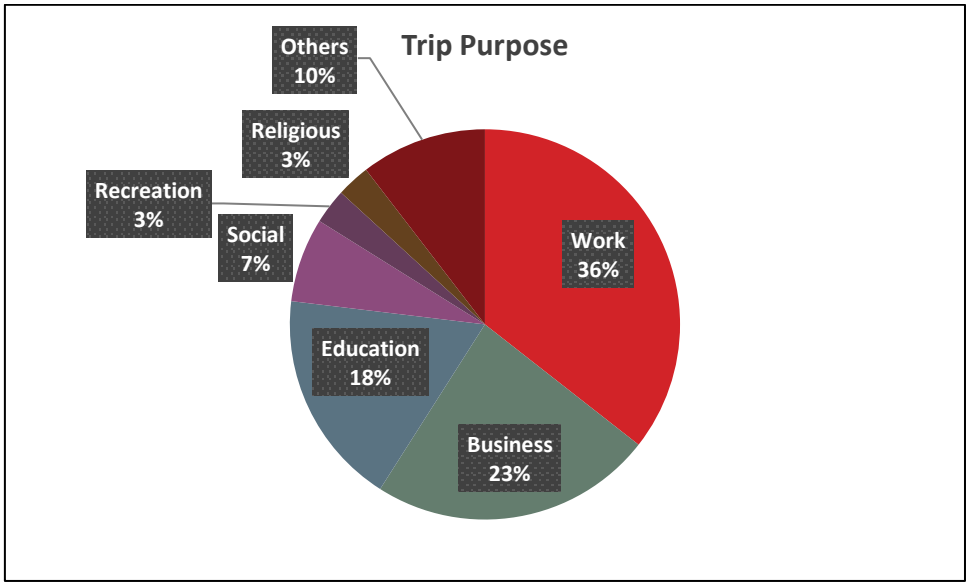


Figure 4-54 Trip Purpose Distribution- Railway Terminal

Majority of the trips are work trips followed by Business trips (together constituting 59%). Recreational trips are only 3%.

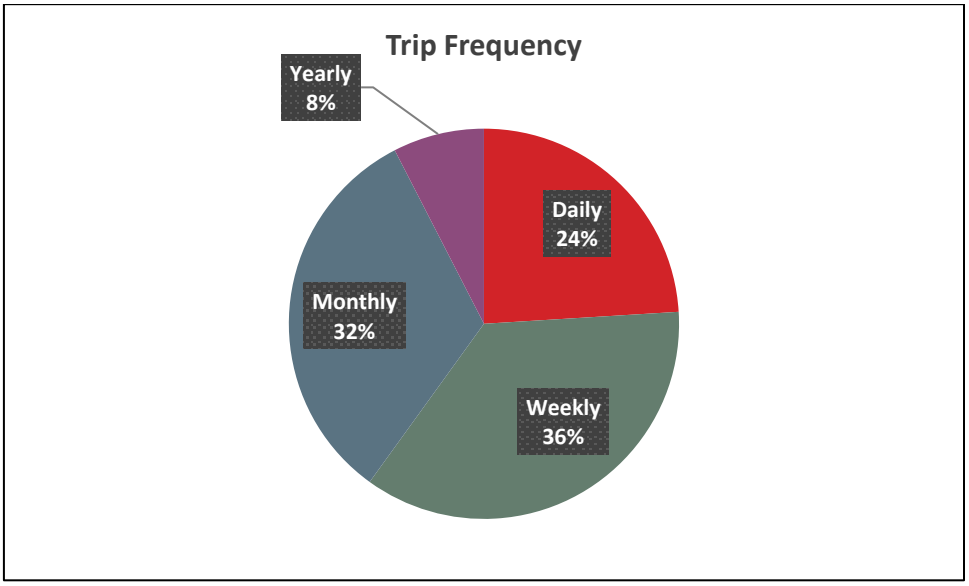


Figure 4-55 Trip Frequency Distribution- Railway Terminal

Majority of the trips are of weekly trips (36%). Monthly trips constitute 32% and daily trips are only 24%.

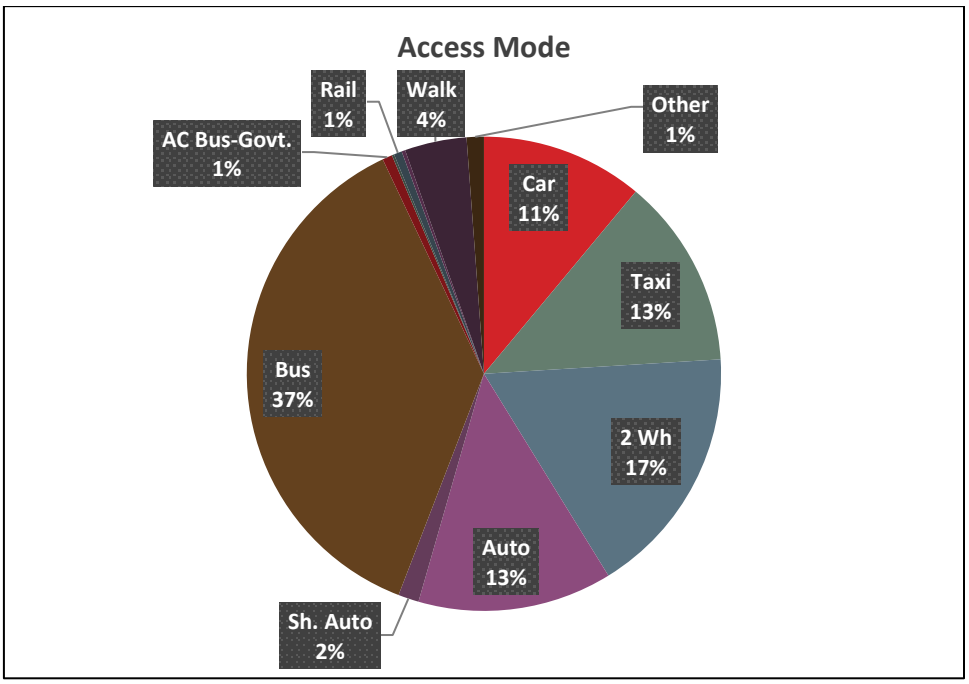


Figure 4-56 Access Mode - Railway Terminal

Ordinary Bus is the major access to Railway Station (37%) followed by two wheeler (17%).

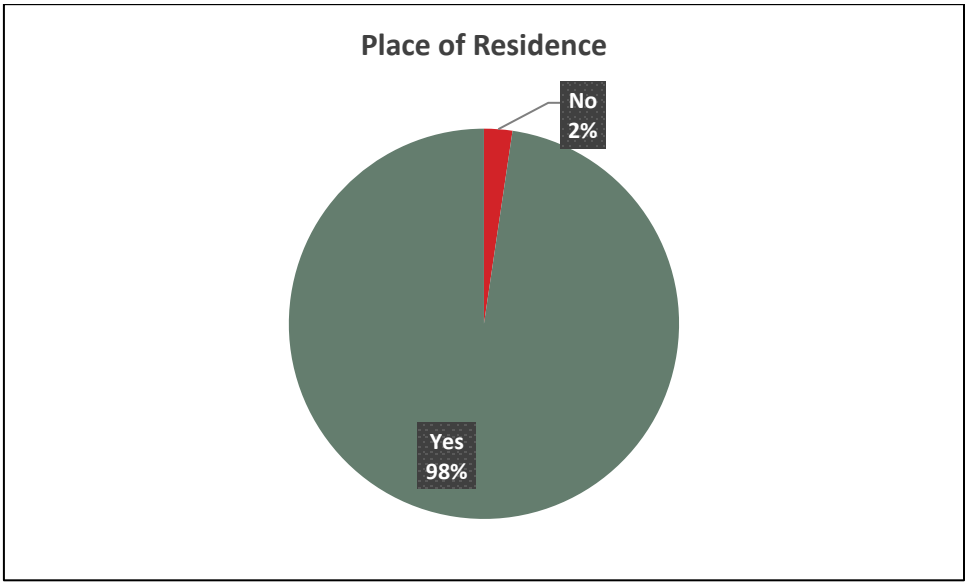


Figure 4-57 Place of Residence - Railway Terminal

Majority of the commuters are Keralites (98%).

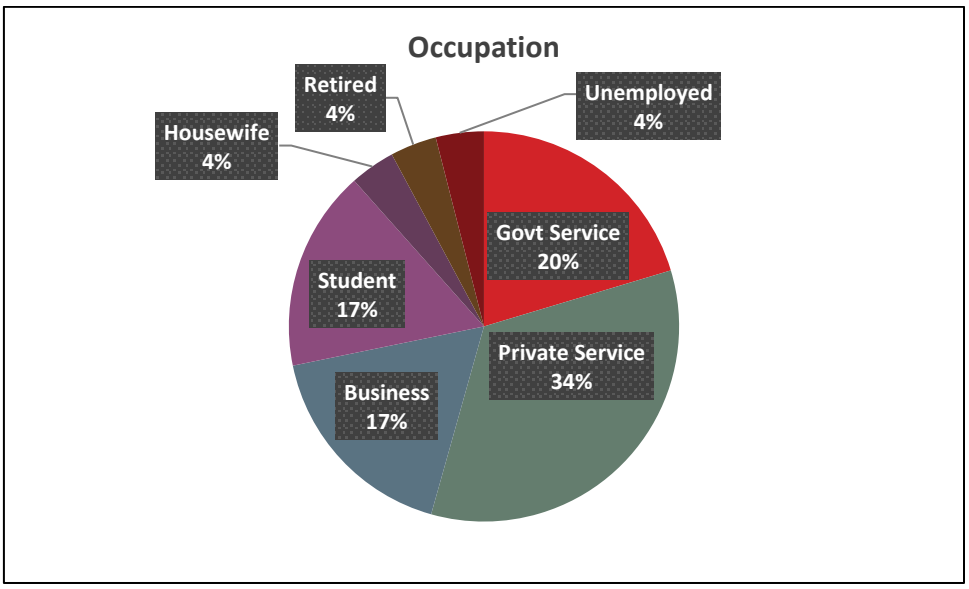


Figure 4-58 Occupation Distribution- Railway Terminal

Occupation of majority of the rail passengers are Private Service and Government Service (34% and 20% respectively).

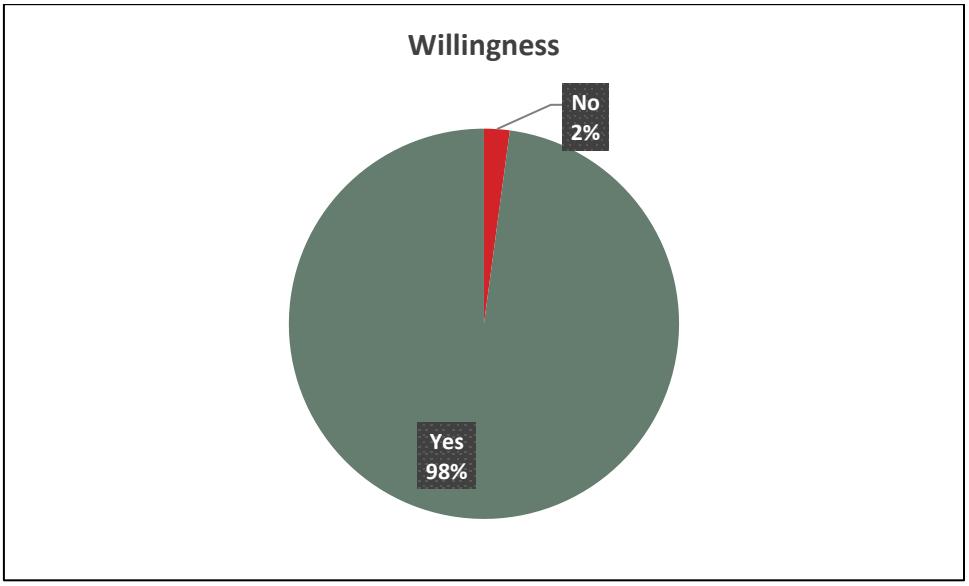


Figure 4-59 Willingness to Shift- Railway Terminal

98% of the rail passengers showed willingness to shift to SilverLine.

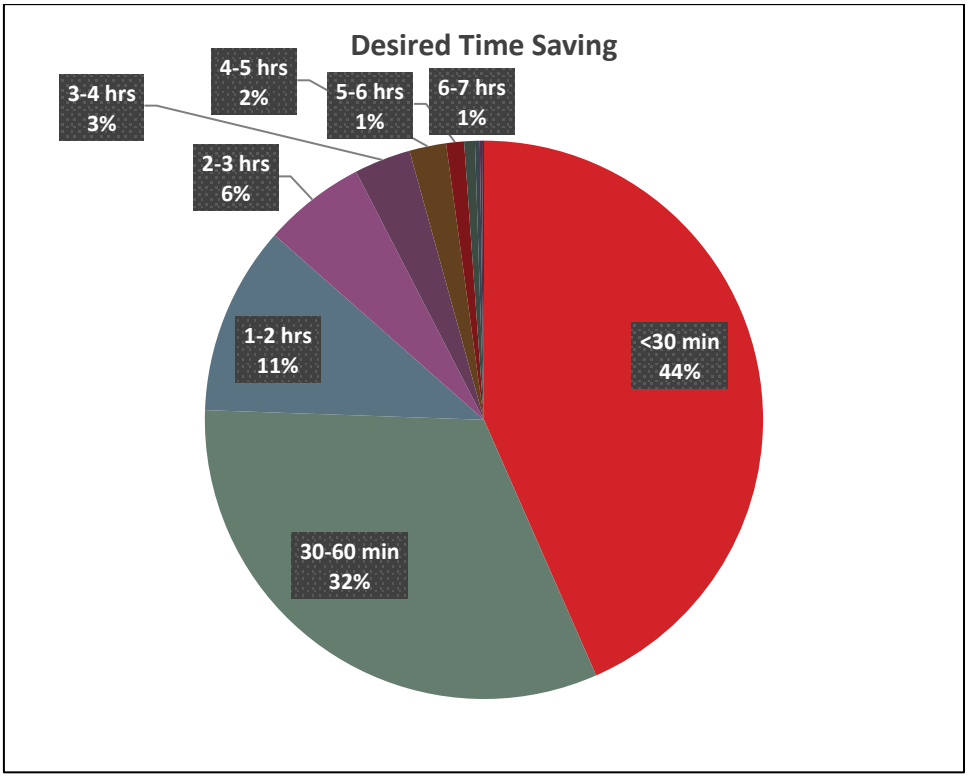


Figure 4-60 Desired Time Saving- Railway Terminal

Desired time saving for majority of the rail users are less than 30 minutes and 30-60 minutes (44% and 32% respectively).

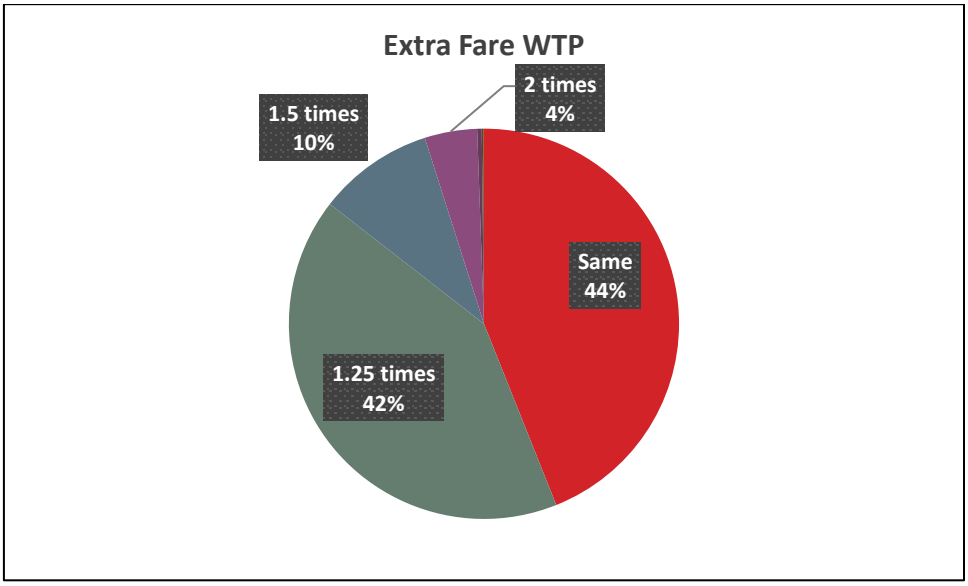


Figure 4-61 Extra Fare Willing To Pay- Railway Terminal

Most of the rail passengers are only willing to pay same fare (44%). 42% and 10% expressed willingness to pay 1.25 and 1.5 times respectively.

4.5 DATA ANALYSIS FROM SECONDARY SOURCES – PASSENGER TRIPS

4.5.1 Railway Reserved Passenger Data

Railway reserved passenger data were collected through *Reserved Passenger Data Warehouse of Indian Railways*. Trains crossing at least 3 SilverLine stations are considered and only AC, Sleeper and Chair Car passengers are treated as potential users. The reserved rail passenger data collected corresponds to the year 2018 (1st January to 31st December). List of trains considered is given in Table 4-27.

Origin Destination matrix of category-wise rail passengers matrix was developed and Origin & destination of the trips are classified as *Internal* or *External* based on their location. Locations within Kerala are termed *internal* and locations outside Kerala are termed *External*.

4.5.2 Major OD Pairs

Major OD pairs are identified for trains plying through Kerala.

Internal (I) - Stations within Kerala ; External (E)- Stations outside Kerala

Major OD Pairs - within Kerala (Internal to Internal)

- Thiruvananthapuram Central- Ernakulam (1.94% of total, 6.66% of I-I)
- Thiruvananthapuram Central- Kozhikode(1.48% of total, 5.08% of I-I)
- Thiruvananthapuram Central- Thrissur (1.39% of total, 4.78% of I-I)
- Ernakulam Junction-Kozhikode (0.85% of total, 2.92% of I-I)

Major OD pairs- Internal to External

- Chennai Central- Kozhikode (1.48% of total, 3.42% of I-E)
- Thrissur- Chennai Central (1.05% of total, 2.42% of I-E)
- Ernakulam town- Chennai Central (0.83% of total, 1.93% of I-E)
- Thiruvananthapuram Central-Chennai Central (0.70% of total, 1.62% of I-E)

Major OD pairs- External to External

- Chennai Central- Mangalore Central (0.98% of total, 3.54% of E-E)
- Coimbatore Junction- Chennai Central (0.72% of total, 2.61% of E-E)

Distribution of Internal -Internal, Internal - External and External - External rail passengers trips are shown in **Figure** 4-62**.**

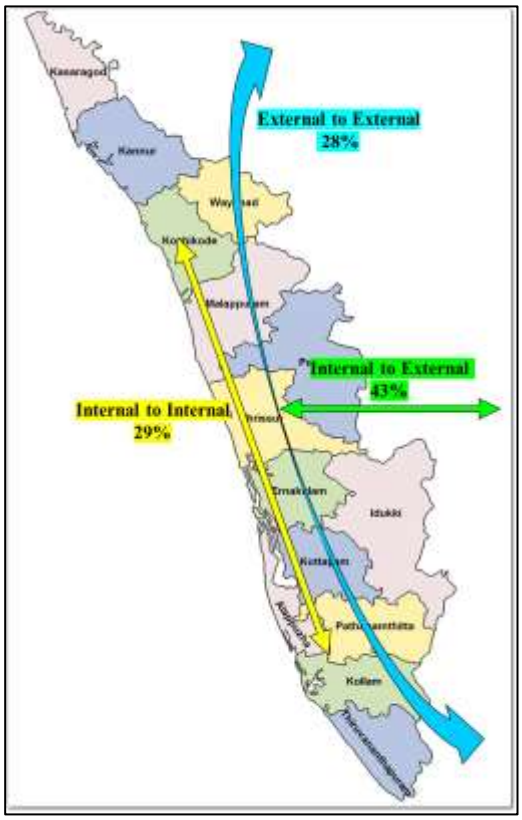


Figure 4-62 Distribution of Railway Reserved Passengers

4.6 TOLL TRAFFIC DATA - SCF ESTIMATION

Monthly tollable traffic at Paliyekkara and Kumbalam toll plaza are used in assessment of Seasonal Correction Factors. The estimated SCF for Paliyekkara and Kumbalam toll plaza are given in tables below. However, these SCF are not used for AADT estimation, since data of only two stretches/ toll plazas is available and it cannot be considered as representative of entire corridor.

Table 4-47: Seasonal Correction Factors- Paliyekkara Toll Plaza

Month	SCF					
	LMV	LCV	TRUCK	BUS	MAV	TOTAL
Sep-16	0.94	0.97	1.01	1.00	1.01	0.95
Oct-16	0.92	0.88	0.95	0.95	0.95	0.92
Sep-17	1.09	1.07	1.07	1.11	1.10	1.09
Oct-17	1.16	1.03	1.06	1.00	1.09	1.13
Sep-18	1.20	0.98	0.91	1.08	0.92	1.13
Oct-18	1.05	0.93	0.94	1.09	0.95	1.03
Sept.- Average	**1.08**	**1.01**	**1.00**	**1.07**	**1.01**	**1.06**
Oct.- Average	**1.05**	**0.95**	**0.98**	**1.01**	**0.99**	**1.03**

Table 4-48: Seasonal Correction Factors- Kumbalam Toll Plaza

Month	SCF						
	Car	LCV	BUS	Truck	3Axle	4-6 Axle HCM/EME/MAV	Total Vehicles
Sep-17	0.93	1.11	1.09	1.07	1.12	1.03	0.97
Oct-17	1.07	1.02	1.01	0.96	1.06	0.98	1.05
Sep-18	1.08	0.93	1.02	0.96	0.98	0.90	1.04
Oct-18	1.09	1.00	1.00	0.89	0.96	0.91	1.05
Sep-19	0.98	1.18	1.16	1.14	1.24	1.15	1.02
Oct-19	1.06	1.10	1.06	1.02	1.12	1.06	1.07
Sept.- Average	**1.00**	**1.08**	**1.09**	**1.06**	**1.11**	**1.03**	**1.01**
Oct.- Average	**1.07**	**1.04**	**1.02**	**0.96**	**1.05**	**0.98**	**1.06**

4.7 BUS PASSENGER TRIPS DATA - THIRUVANANTHAPURAM CENTRAL

Bus Passenger trips data from Thiruvananthapuram Central were collected for the month of October, 2019 from KSRTC (Kerala State Road Transport Corporation). The data is

compiled to obtain route wise summary for October 2019 and the same is given in **Table 4-49.**

Table 4-49: Route Wise Summary - October,2019

Route	No. of Schedules	Scheduled Km	Operated Km	Total Collection	Total Passengers	Earnings per Km	Earnings per Bus
Additional Services	42	23479	20071	835895	13487	41.65	19902
Thiruvananthapuram-Bangalore	115	185719	185445	10137896	17097	54.67	88156
Thiruvananthapuram-Cape	30	15540	14429	452125	12786	31.33	15071
Thiruvananthapuram-Coimbatore	294	236558	246622	11852103	119138	48.06	40313
Thiruvananthapuram-Erumely	26	15392	13638	520365	12056	38.16	20014
Thiruvananthapuram-Katapana	31	19065	19060	815816	11683	42.80	26317
Thiruvananthapuram-Kannur	24	25320	25302	1433217	3003	56.64	59717
Thiruvananthapuram-Kanyakumari	62	32116	30574	971534	26126	31.78	15670
Thiruvananthapuram-Kowayam	26	15808	13982	445809	13041	31.88	17147
Thiruvananthapuram-Kozhikode	179	152288	153153	5733428	60784	37.44	32030
Thiruvananthapuram-Kumily	31	14477	14472	548913	11976	37.93	17707
Thiruvananthapuram-Mangalapuram	21	28623	27331	1338461	3146	48.97	63736
Thiruvananthapuram-Mattupetty	29	18270	18293	789335	12879	43.15	27218
Thiruvananthapuram-Mookambika	31	50623	49415	2666427	4676	53.96	86014
Thiruvananthapuram-Munnar	31	18662	19242	749942	12840	38.97	24192
Thiruvananthapuram-Mysore	40	50982	50039	2983897	5523	59.63	74597
Thiruvananthapuram-Nedumkandam	87	48588	47814	1788060	37482	37.40	20552
Thiruvananthapuram-Nilambur	30	24270	24275	782323	4680	32.23	26077
Thiruvananthapuram-Palakkad	178	127796	127405	4836117	67043	37.96	27169
Thiruvananthapuram-Palani	44	41360	41361	1666976	25243	40.30	37886
Thiruvananthapuram-Pamba	31	11284	11648	490504	13064	42.11	15823
Thiruvananthapuram-Pengamukku	27	18171	18337	975033	15851	53.17	36112
Thiruvananthapuram-Sulthanbathery	31	32922	32674	1085932	7161	33.24	35030
Thiruvananthapuram-Thenkasi	243	120048	119551	4574666	120789	38.27	18826

Route	No. of Schedules	Scheduled Km	Operated Km	Total Collection	Total Passengers	Earnings per Km	Earnings per Bus
Thiruvananthapuram-Thiruvilwamal	28	19628	19190	895607	14589	46.67	31986
Thiruvananthapuram-Thrissur	151	88315	88328	3741586	64161	42.36	24779
Thiruvananthapuram-Vazhikkadavu	29	24911	25155	1084850	16842	43.13	37409

Maximum number of bus trips and passengers are on Thiruvananthapuram- Tenkasi and Thiruvananthapuram- Coimbatore routes. Details of total bus trips in Thiruvananthapuram Central is given in **Table** 4-50**.**

Table 4-50: Total Bus Trips Summary - October, 2019

Total trips	Total Scheduled Km	Total Operated Km	Total Collection	Total Passengers	Earnings per Km	Earnings per Bus
1891	1460215	1456806	64196817	727146	44.07	33949

4.8 DATA ANALYSIS FROM SECONDARY SOURCES - GOODS

Survey of truck operators and cargo forwarding agencies, located in Kerala and border districts of Tamil Nadu and Karnataka, was carried out, to collect information on the operational characteristics of goods vehicles. To identify characteristics of existing cargo being transported by Railways, surveys are conducted regarding Railway Parcel Services, at 5 major cargo handling stations in Kerala. This section details the characteristics of trips as observed from data collected.

4.8.1 Data Analysis of Truck Operators

Characteristics of truck operator trips analysed from the data collected are given in **Figure** 4-63 to **Figure** 4-69.

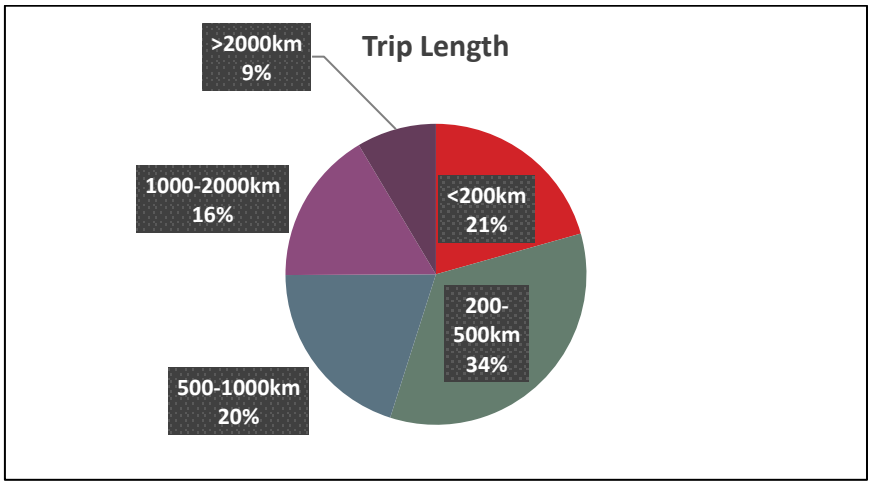


Figure 4-63 Trip Length Distribution- Truck Operator Data

Majority of the trips has a trip length between 200 and 500 km (34%). Trip length greater than 2000 km is only 9%.

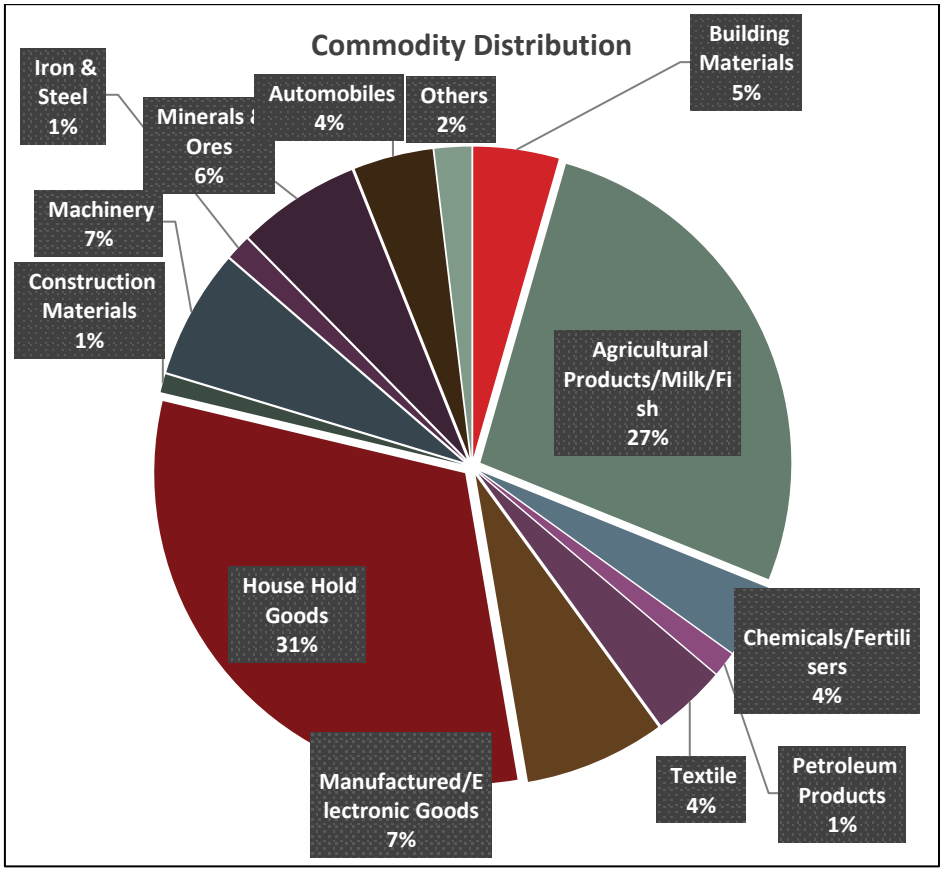


Figure 4-64 Commodity Distribution- Truck Operator Data

Majority of the goods being transported are Building materials (31%) and Agricultural products/ Milk/ Fish (27%).

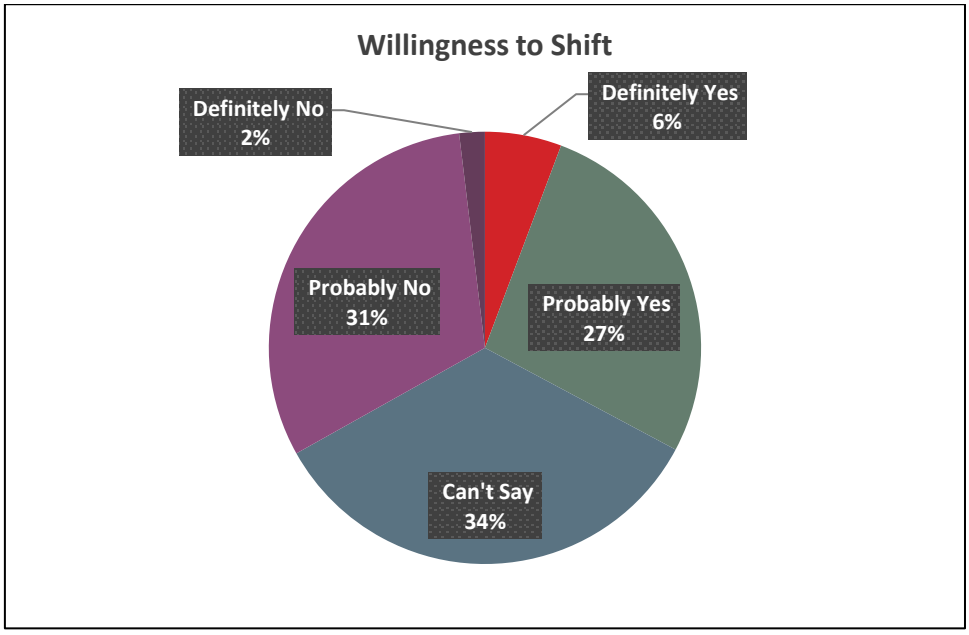


Figure 4-65 Willingness to Shift to RORO - Truck Operator Data

Only 6% respondents expressed *Definitely Yes* to Shift to RORO service.

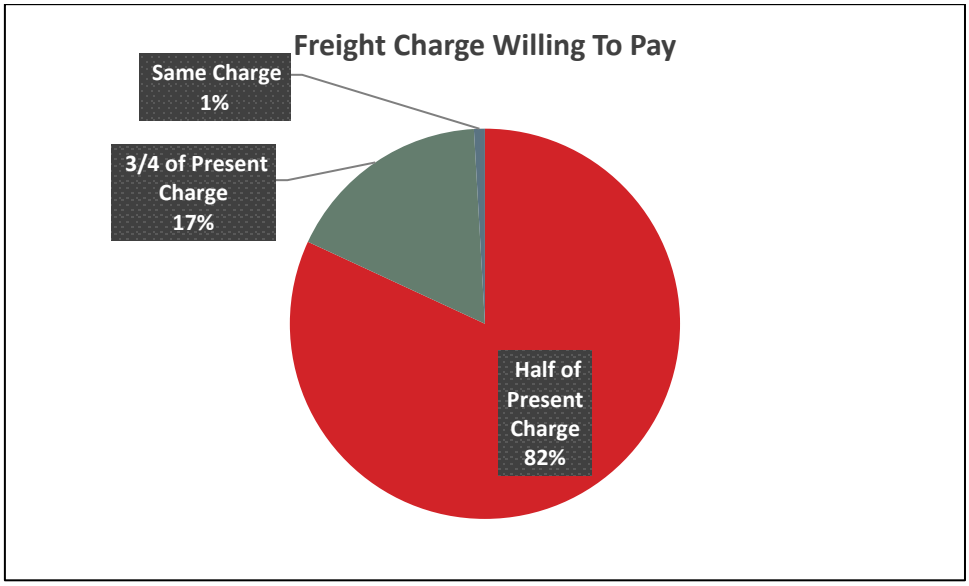


Figure 4-66 Freight Charge Willing To Pay - Truck Operator Data

82% of the respondents expressed Willingness to Pay half of the present charge they are paying. Only 1% showed willingness to pay existing charge.

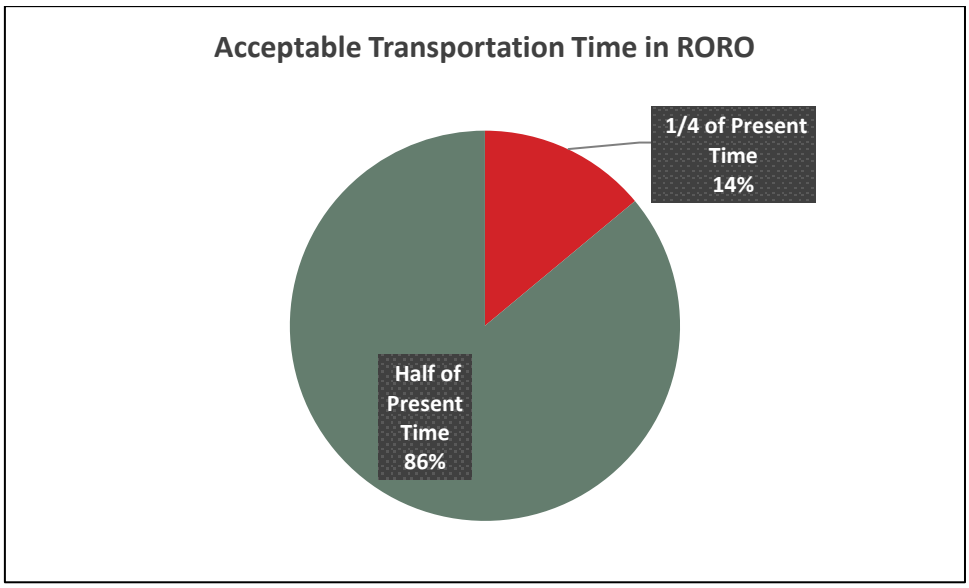


Figure 4-67 Acceptable Transportation Time in RORO - Truck Operator Data

86% of respondents expressed half the present time as acceptable time of transportation in RORO.

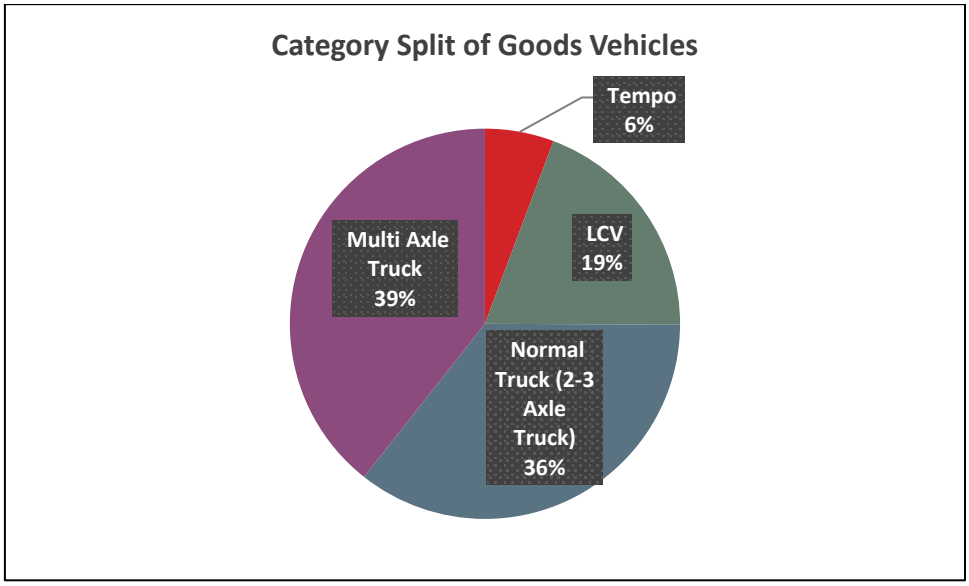


Figure 4-68 Category Split of Goods Vehicles - Truck Operator Data

Major category of goods vehicles used for transport is Multi Axle Trucks (39%), followed by 2-3 Axle trucks (36%).

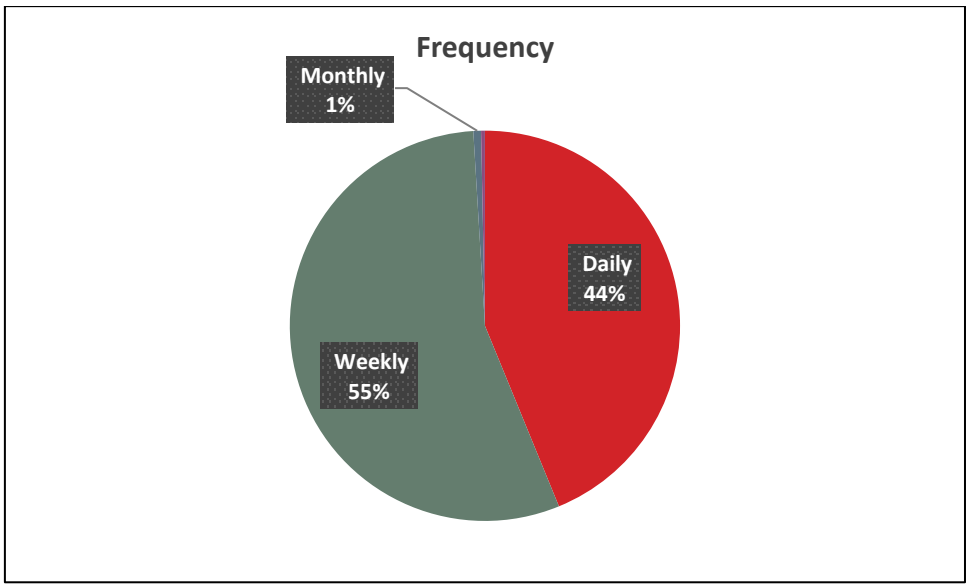


Figure 4-69 Frequency Distribution- Truck Operator Data

Majority of the trips are of *weekly* (55%), followed by *Monthly* trips (44%).

4.8.2 Data Analysis of Cargo Forwarding Agencies

Characteristics of trips by cargo forwarding agencies identified from data collected are given in **Figure** 4-70 to **Figure** 4-75.

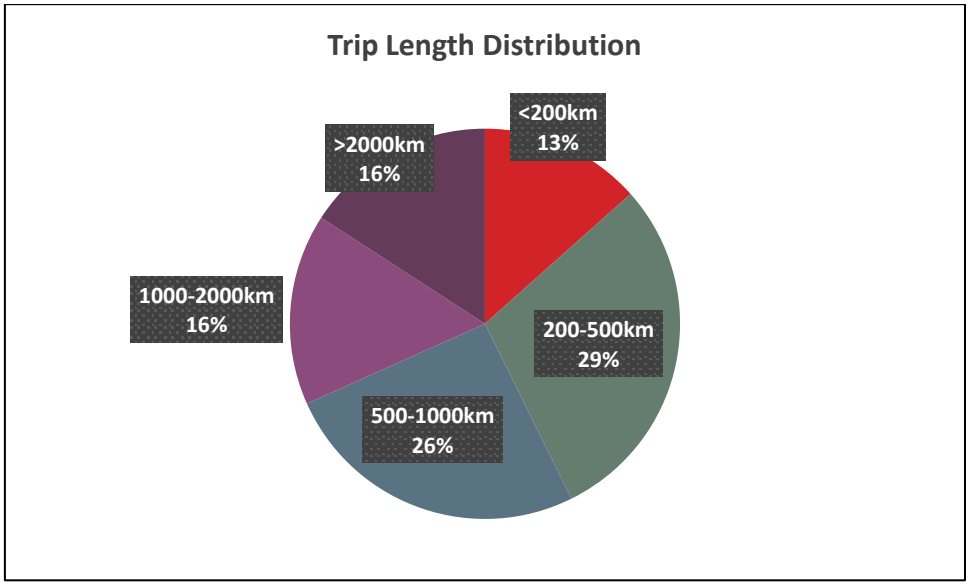


Figure 4-70 Trip Length Distribution - Cargo Forwarding Agencies

Majority of the trips (29%) has a trip length between 200 and 500 km and trip length greater than 2000km is only 16%.

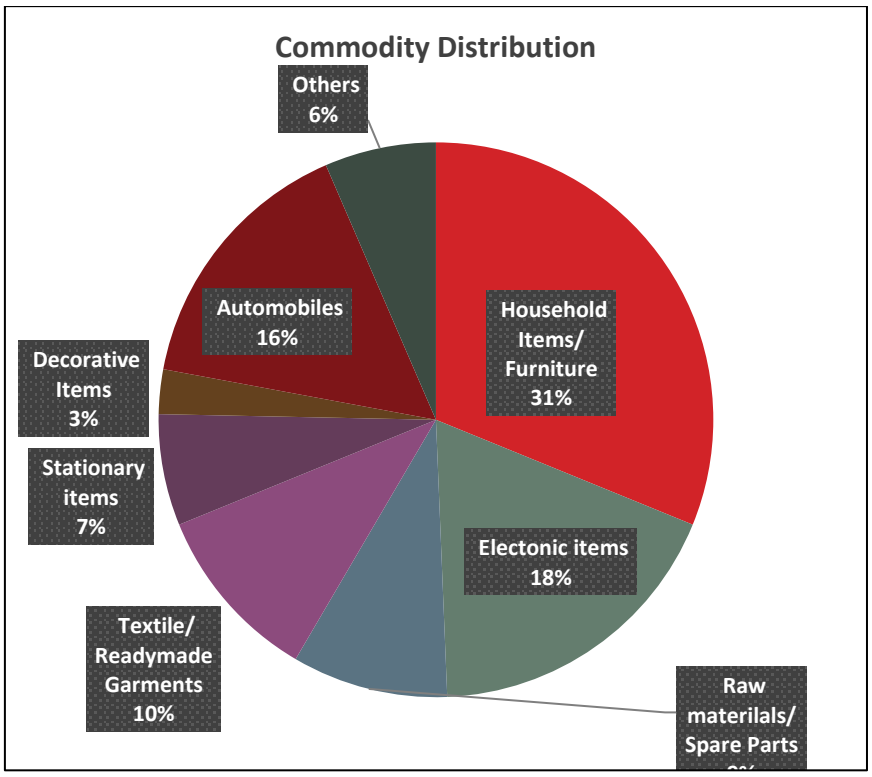


Figure 4-71 Commodity Distribution- Cargo Forwarding Agencies

Majority of the goods being transported are Household Items/Furniture (31%) and Electronic Items (18%).

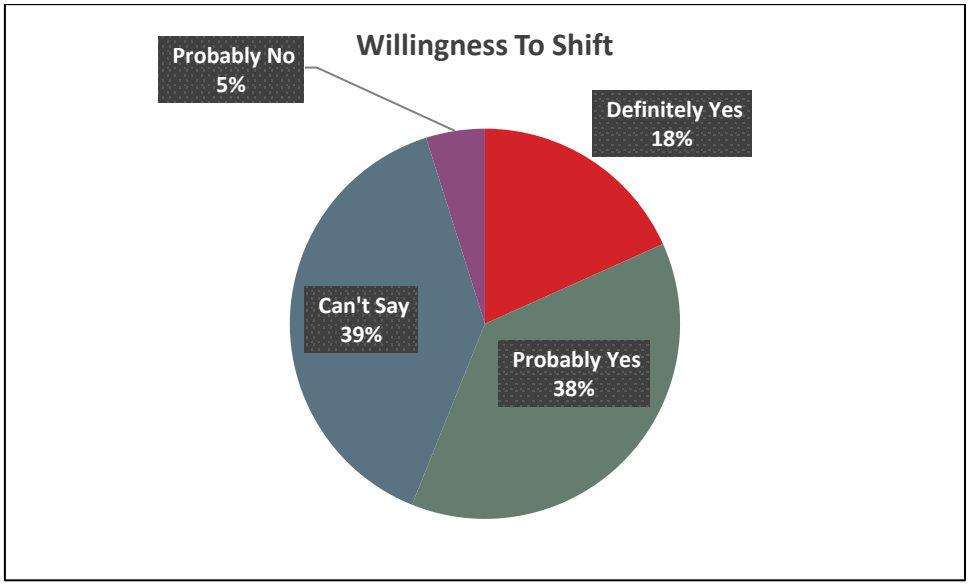


Figure 4-72 Willingness to Shift to RORO- Cargo Forwarding Agencies

Only 18% of respondents indicated *Definitely Yes* to shift to RORO service.

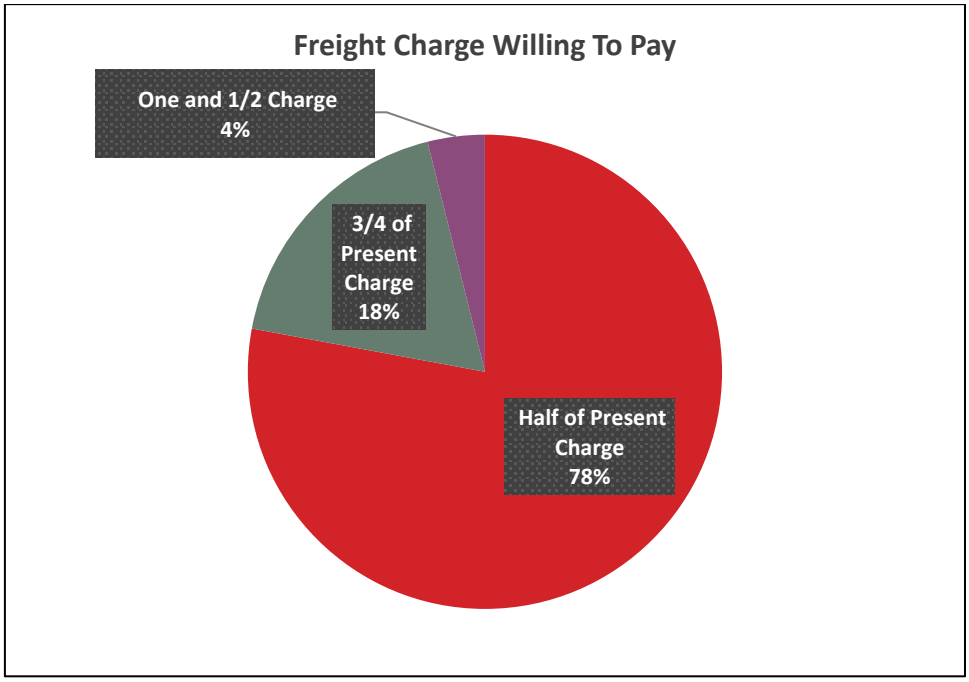


Figure 4-73 Freight Charge Willing To Pay - Cargo Forwarding Agencies

72% of the respondents expressed willingness to pay half of present charge. Only 4% showed willingness to pay one and half times present charge.

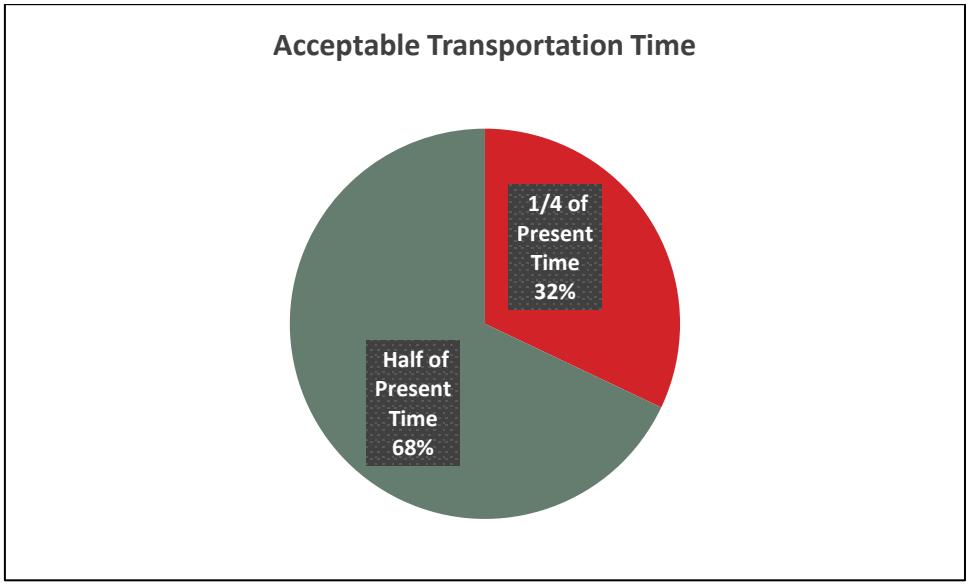


Figure 4-74 Transportation Time in RORO- Cargo Forwarding Agencies

68% of respondents expressed half the present time as acceptable time of transportation in RORO Service.

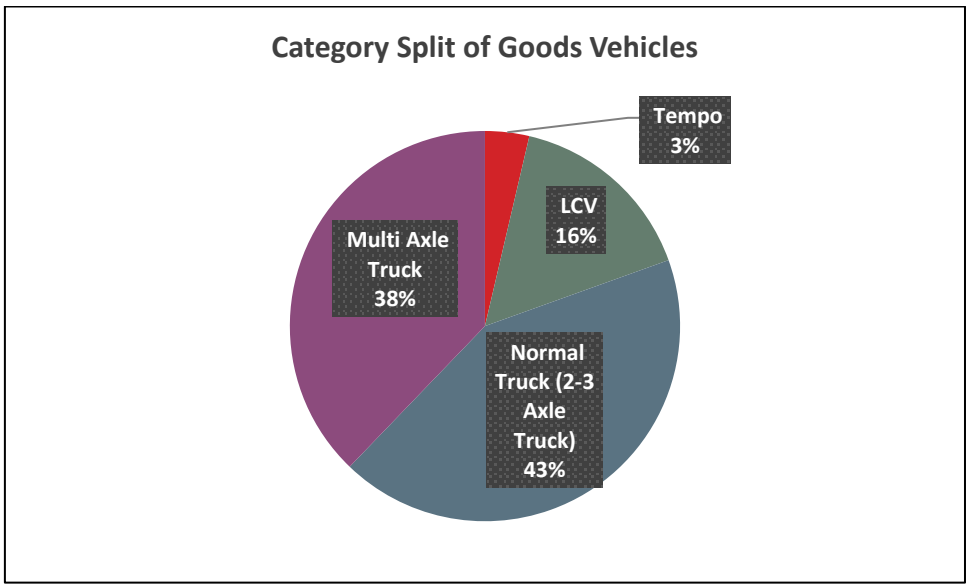


Figure 4-75 Category Split of Goods Vehicles - Cargo Forwarding Agencies

Major category of goods vehicle used for transport is 2-3 Axle trucks (43%) followed by Multi Axle trucks (38%).

4.8.3 Data Analysis of Rail Parcel Services

Characteristics of Railway Parcel Services identified from data collected are given in **Figure** 4-76 and **Figure** 4-77.

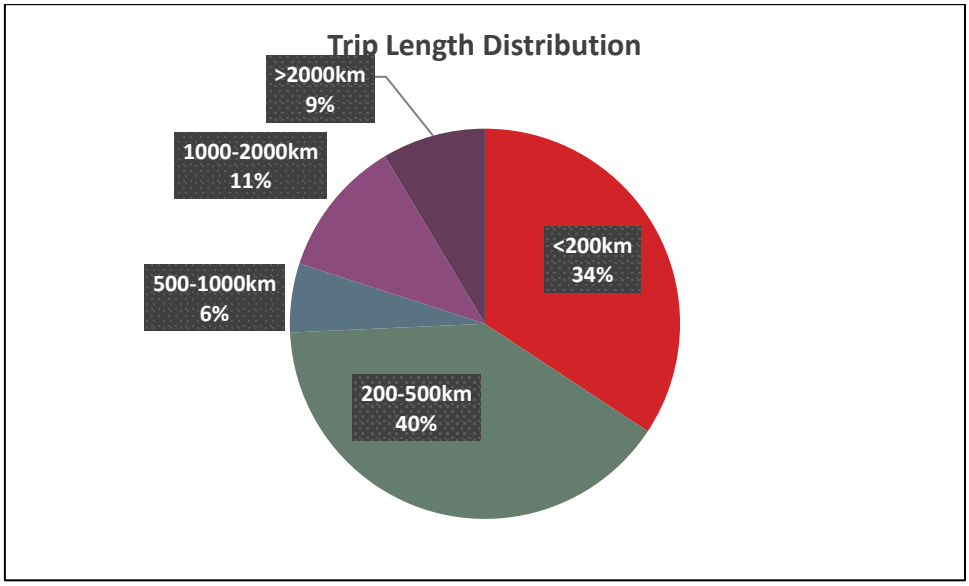


Figure 4-76 Trip Length Distribution- Rail Parcel Service

Majority of the trips has a trip length of 200 and 500 km (40%) and trip length greater than 2000 km is only 9%.

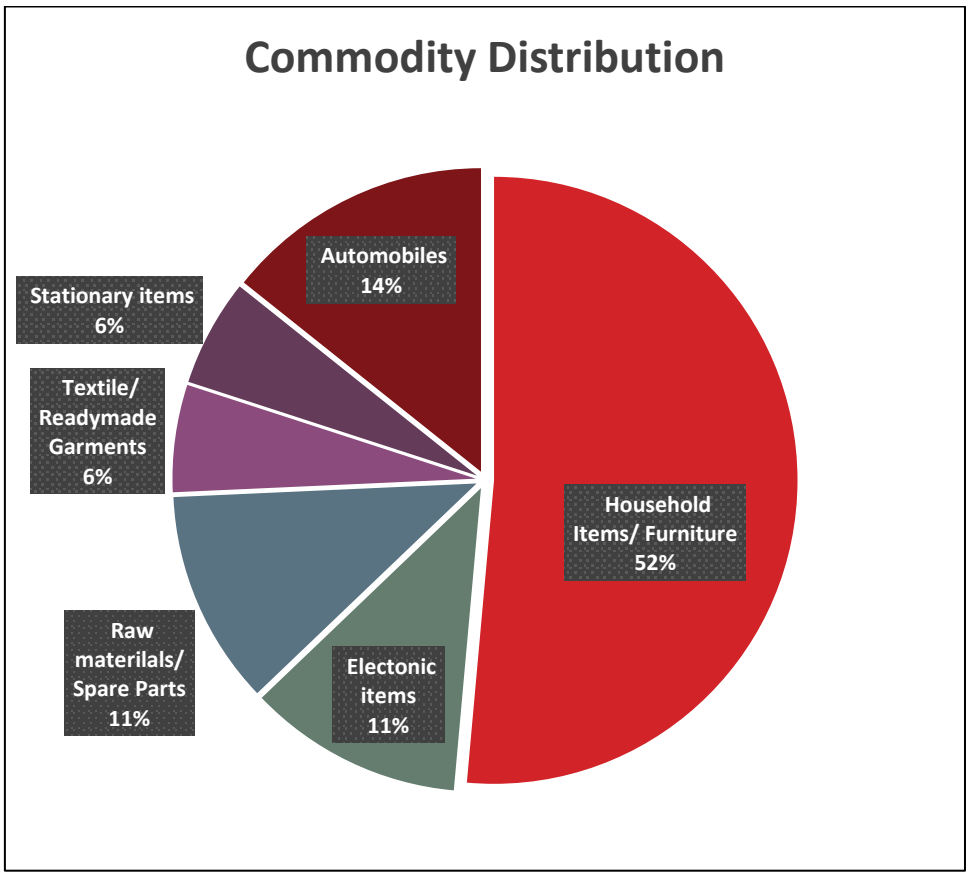


Figure 4-77 Commodity Distribution- Rail Parcel Service

Majority of the goods being transported are Household Items/ Furniture(52%) and Automobiles (14%).

4.8.4 Railway Goods Traffic at Thiruvananthapuram Division

Goods/ freight traffic data in Thiruvananthapuram division is collected from Ministry of Railways through K-Rail. The data collected have details of freight trips during April to October, 2019. Analysis of the data is presented in this section. Summary of originating traffic in Thiruvananthapuram division is given in **Table** 4-51**.**

Table 4-51: Originating Traffic - Summary

No. of Railway Receipts	1686
No. of wagons	36090
Invoice Weight in tonnes	2097601
Freight Charge collected, Rs.	2325033120
Net tonne kilometre, NTKM	1163773391

Summary of inward traffic in Thiruvananthapuram division is presented in **Table** 4-52**.**

Table 4-52: Inward Traffic - Summary

No of Wagons unloaded	16464
No of bags	15265900
Weight in tonnes	1045062

Major destination stations and corresponding percentage of weight of goods are given below:

- The Ramco Cements Ltd siding, Ariyalur- 7.41%
- Devangonthi Oil Siding- 11.86%
- The Ramco Cements Limited, siding, Ichchangadu - 4.42%
- Indian Oil Corporation, siding Ferok - 14.04%
- Tirunelveli- 8.41%

Major Receiving Stations of inward traffic and corresponding percentage of weight of goods are given below:

- Aluva- 12.97%
- Chalakudi- 10.49%
- Kalamassery- 17.60%
- Kottayam- 7.72%
- Nagercoil Junction- 7.45%

Commodity distribution of originating traffic based on weight in tonnes is given in **Figure** 4-78. Major goods transported are Aviation turbo fuel(27%), Fertilisers (24%) and Diesel (24%).

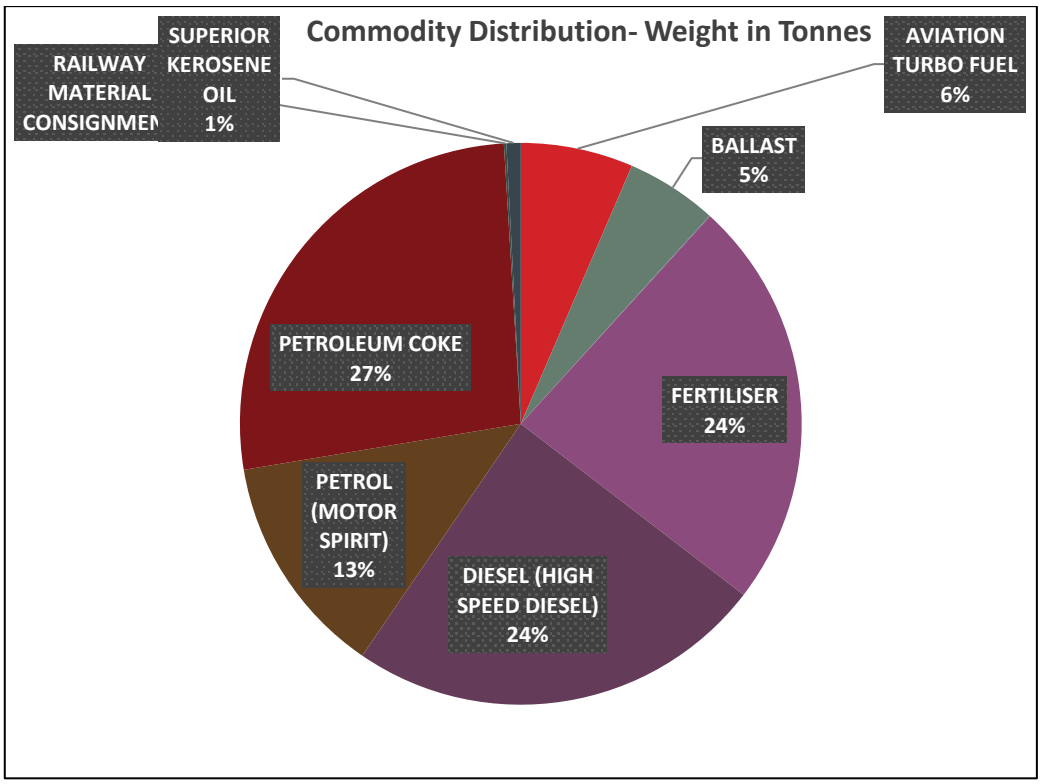


Figure 4-78 Commodity Distribution based on Weight - Originating Traffic

Commodity distribution of originating traffic based on Net Tonne Kilometre (NTKM) is given in **Figure** 4-79. Major goods transported are Aviation turbo fuel (27%), Fertiliser (36%) and Diesel (19%).

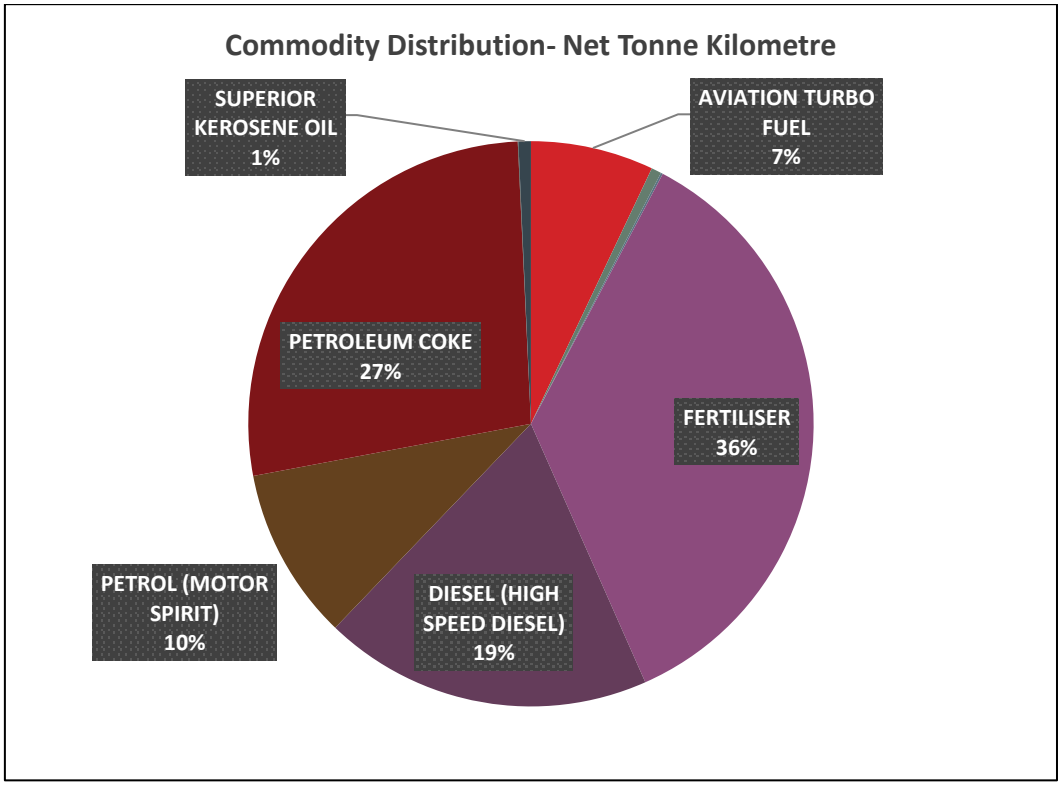


Figure 4-79 Commodity Distribution based on NTKM- Originating Traffic

Consignor distribution of originating traffic based on weight in tonnes is given in **Figure** 4-80. Major consignor is BPCL with 71% contribution.

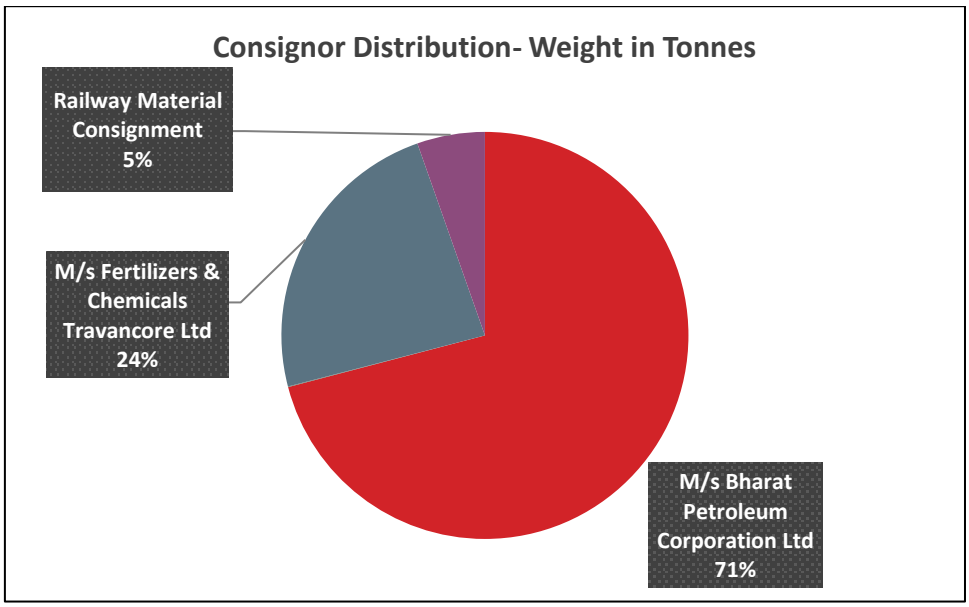


Figure 4-80 Consignor Distribution based on Weight- Originating Traffic

Origin distribution of originating traffic based on weight in tonnes is given in **Figure 4-81**. Major origin stations are BPCL, Irimpanam (44%) and BPCL, Kochi Refinery (27%).

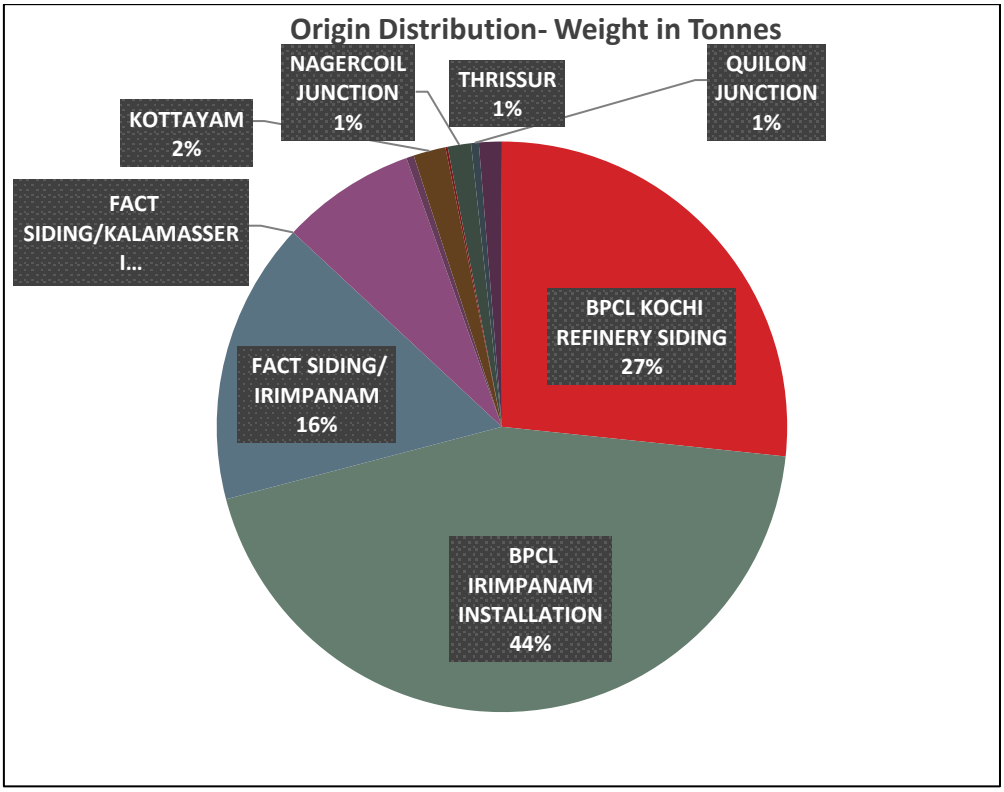


Figure 4-81 Origin Distribution based on Weight - Originating Traffic

4.9 ESTIMATION OF POTENTIAL TRIPS

Potential trips are the most probable passengers who are potential to use SilverLine. This section describes estimation of potential trips from Train, Car/ Taxi, bus and potential airport trips. In case of train only AC Class, Sleeper and Chair Car passengers are considered as potential users. In case of car/ taxi and bus passengers, the trips are filtered from total traffic based on trip length. Details and criteria of potential trips estimation is given in subsequent sections.

The potential trips from airport is estimated based on the terminal OD survey conducted at each of the airport and based on the trip lengths and main mode of travel from and to airports.

4.9.1 Potential Trips - Railway Passengers

Data of passengers travelling under reservation obtained through Railways Datawarehouse, Centre for Railway Information Systems (CRIS) Reports and Unreserved Ticketing System (UTS) data from Thiruvananthapuram and Palakkad divisions of Southern Railway was used in estimation of potential trips from railway.

4.9.1.1 From CRIS Data

Data corresponding to trains crossing at least 3 SilverLine station were collected. Only AC, Sleeper and Chair Car passengers were considered as potential users. The

passenger traffic data corresponds to the year 2018 (1st January to 31st December). Details of the trains considered is given in Table 4-27.

Reserved Railway Passenger Data compiled from *Data Warehouse* is used in preparing the OD matrix of passenger trips. Origin and destination are classified as *Internal* and *External* based on their locations. Stations within Kerala are classified as *Internal* and Outside Kerala as *External*. External to External trips are discarded in candidate traffic estimation.

Potential candidate traffic from Railway Passengers for the year 2018 is **70320.** Category wise number of railway passengers is given in **Table** 4-53**.**

Table 4-53: Category Wise Rail Passengers

OD Pair	1A	2A	2S	3A	CC	SL	All Classes
Internal –Internal	21	739	11615	2914	2734	10220	28242
Internal –External	96	2355	769	9546	311	29001	42077
External –External	57	1505	59	4646	56	20561	26885
Total	**174**	**4599**	**12443**	**17105**	**3101**	**59782**	**97204**
Candidate traffic (I-I + I-E)	**116**	**3094**	**12384**	**12459**	**3045**	**39221**	**70320**
% of Total Candidate traffic	**0.2%**	**4.4%**	**17.6%**	**17.7%**	**4.3%**	**55.8%**	**100.0%**

Internal (I) - Stations within Kerala ; External (E)- Stations outside Kerala
Candidate traffic = Internal – Internal(I-I) Passengers + Internal – External(I-E) Passengers.

Apart from the above data, UTS data was also collected and analysed and the details are provided below.

4.9.1.2 From UTS Data

Unreserved ticketing data from Palakkad and Thiruvananthapuram division for the month of November 2019 was collected from the Southern Railways. The data included source station, destination, fare, class type and number of tickets issued from each of the stations. A normal week data was then extracted for further analysis. During analysis following were the assumptions considered:-

1) Trips with fare greater than Rs. 45/- per ticket was extracted. This is based on assumption that a passenger may be travelling on an express train.
2) Season tickets were removed from the data for analysis
3) The minor stations within the major stations were made as clusters, they are:-
    a. Thiruvananthapuram - TVM, TVP, KCVL, KZK
    b. Kollam - QLN, VAK
    c. Kottayam - KTYM, ETM

d. Ernakulam - ERS, ERN, TRTR, IPL, KLMR
e. Trissur - TCR, PUK, WKI
f. Tirur - TIR, TUA, KTU, TA, PGI
g. Kozhikode - CLT, KUL, VLL, WH
h. Kannur - CAN, CS
i. Kasargode - KGQ, KZE, BFR, MJS

4) All stations beyond Neyantinkara, Shornur, Manjeshwaram was considered as external to SilverLine main line
5) All small stations along the project corridor coded as AGGREGATOR

Based on the above assumptions, the potential trips from UTS data is as follows:-

Table 4-54: Category Wise Rail (UTS) Passengers

ORIGIN/DESTINATION	THIRUVANANTHAPURAM	KOLLAM	CHENGANNUR	KOTTAYAM	ERNAKULAM	TRISSUR	TIRUR	KOZHIKODE	KANNUR	KASARGODE	GRAND TOTAL
THIRUVANANTHAPURAM	0	0	0	1242	1594	705	157	388	199	100	**4385**
KOLLAM	0	0	0	0	1047	360	72	158	61	35	**1732**
CHENGANNUR	0	0	0	0	0	358	42	82	30	12	**523**
KOTTAYAM	1200	0	0	0	0	0	39	122	59	38	**1458**
ERNAKULAM	1702	1183	0	0	0	0	0	1212	617	216	**4929**
TRISSUR	610	427	329	0	0	0	0	0	393	111	**1870**
TIRUR	133	89	41	37	0	0	0	0	0	252	**552**
KOZHIKODE	274	157	73	109	937	0	0	0	0	0	**1550**
KANNUR	139	83	29	51	502	277	0	0	0	0	**1080**
KASARGODE	89	52	18	46	204	120	251	0	0	0	**780**
GRAND TOTAL	**4147**	**1992**	**489**	**1485**	**4285**	**1819**	**560**	**1960**	**1359**	**763**	**18860**

The potential traffic (Internal to Internal) is estimated to be 18860 and Internal to external trips such as trips to Chennai, Salem, Erode etc., is estimated to be 2796 trips. So, total potential trips from UTS data is estimated to be **21656** trips.

4.9.2 Potential Trips - Buses

Data collected from OD survey at 9 locations is combined avoiding duplication of data. Combined data is used to form an OD matrix of different type of buses, such as for private AC bus, KSRTC AC and non-AC buses etc.

To avoid vehicles which might have travelled transverse to project corridor, a buffer zone of 15 km radial distance from SilverLine alignment was considered. In order to arrive at the target group of Car/Taxi users, trips with trip length less than 50 km are discarded, if both origin and destination are within buffer zone. Similarly trips with trip length less than 75 km and 100 km are discarded if either origin or destination is outside buffer zone and if both origin and destination is outside buffer zone respectively. Candidate traffic from buses for the year 2019 are provided in the table below:-

Table 4-55: Type-Wise Bus Potential Passengers

Sl. No.	Bus Type	Potential Traffic
1	AC BUS-PVT.	9875
2	AC LOW FLOOR BUS-KSRTC	11433
3	AC BUS-KSRTC	17331
4	DELUXE BUS	15262
5	EXPRESS BUS	11000
6	SUPER FAST BUS	47081
7	FAST PASSENGER BUS	20691
8	ORDINARY BUS	35629
9	MINI BUS	19348
Grand Total	**Sl.No. 1 to Sl.No. 7**	**132673**
Grand Total	Sl.No. 1 to Sl.No. 5	64901
Grand Total	Sl.No. 1 to Sl.No. 6	111982

4.9.3 Potential Trips - Cars/ Taxi

Data collected from OD survey at 9 locations is combined avoiding duplication of data. Combined data is used to form an OD matrix of Car and Taxi trips.

To avoid vehicles which might have travelled transverse to project corridor, a buffer zone of 15 km radial distance from SilverLine alignment was considered. In order to arrive at the target group of Car/Taxi users, trips with trip length less than 50 km are discarded, if both origin and destination are within buffer zone. Similarly trips with trip length less than 75 km and 100 km are discarded if either origin or destination is outside buffer zone and if both origin and destination is outside buffer zone respectively. Candidate traffic from Car/Taxi is estimated as **158271** for the year 2019.

4.9.3.1 Major OD Pairs

Major OD pairs in the identified candidate traffic for Car/ Taxi trips are given below. Percentage contribution of each OD pair is also given:

- Thrissur- Ernakulam (5.71%)
- Kollam City- Thiruvananthapuram City (5.23%)
- Kannur city – Kozhikode City (4.01%)
- Ernakulam- Thrissur City (1.76%)
- Ernakulam- Thiruvananthapuram City(1.66%)
- Kasaragod Town- Kannur City(1.56%)

4.9.4 Potential Trips from Airport

Apart from above, the trips from and to airports are also found to be potential as the four airports are accessed by both private and public transport modes by the air travellers. To arrive at potential trips, the airport survey samples were extrapolated to the passenger (by type – International & domestic) handled at each airport. The passenger traffic handled by each of the airport in the month of October 2019 are provided in the **Table 4-56** provided below.

Table 4-56: Passenger traffic handled at airports in Kerala – October 2019

Monthly Traffic			Daily		
Airport	International	Domestic	International	Domestic	Total
Thiruvananthapuram	183076	133949	5906	4321	10227
Calicut	219117	38225	7068	1233	8301
Cochin	387415	423261	12497	13654	26151
Kannur	65776	70503	2122	2274	4396

Source: AAI Passenger handled in 2019 - Annexure IIIA, B & C

From the above table and based on the proposed alignment of SilverLine, there is potential to shift trips from Cochin International Airport (CIAL) and Thiruvananthapuram International Airport (TRV) as it is located along the proposed SilverLine alignment. To arrive at potential trips from airports, following assumptions are considered:-

a) All trips greater than 150Km trip length are considered as potential trips.

b) Trips within the trip length of 100Km to 150Km and done by using public transport modes such as Rail and bus are considered as potential trips.

c) Apart from airport passengers, the trips made by accompanies are also considered as potential trips. With an airport passenger and travelling by car and taxi, additional 2 accompanies are assumed. It is assumed that atleast 2 accompanies will be arriving at airport taxi and car to see-off or pick up airport passenger.

d) The above assumptions are subject to provision of adequate facilities at airport for passengers by SilverLine Operator (or the Airport Authority) and also by other interventions such as group ticketing and discounts, potter facilities and also check-in facilities at stations. The interventions in terms of facilities to airport passengers are necessary as there is requirement to reduce the interchange penalty for shift of passengers to SilverLine. In absence of the above, there is lower probability of shift from car and taxi.

Based on the above assumptions and analysis of the terminal OD data, the results based on mode-wise distribution of passengers based on trip lengths (Trip Length Frequency Distribution - TLFD) for Kochi airport and Thiruvananthapuram airport are provided in **Table 4-57** and Table 4-53 below.

Table 4-57: Mode-wise TLFD of Daily Airport Pax – Kochi Airport

Sl. No.	Mode	TL <100	TL 100-150	TL 151-200	TL 201-400	TL >400
1	Car	10326	3806	881	76	187
2	Taxi	7310	1530	194	14	7
3	2 Wh	249	173	7	0	0
4	Auto	0	0	0	0	0
5	Sh. Auto	0	0	0	0	0
6	Bus	159	7	0	0	0
7	AC Bus-Govt.	470	14	0	0	0
8	AC Bus-Pvt.	90	76	318	0	0
9	Rail	0	0	0	0	0
10	Cycle	0	0	0	0	0
11	Walk	0	0	0	0	0
12	Other	83	152	7	14	0
	Total	18688	5758	1407	104	193

TL – Trip Length*

Table 4-58: Mode-wise TLFD of Daily Airport Pax – Thiruvananthapuram Airport

Sl. No.	Mode	TL <100	TL 100-150	TL 151-200	TL 201-400	TL >400
1	Car	1446	121	0	0	0
2	Taxi	1808	844	0	0	0
3	2 Wh	0	0	0	0	0
4	Auto	0	0	0	0	0
5	Sh. Auto	0	0	0	0	0
6	Bus	964	0	362	0	0
7	AC Bus-Govt.	0	0	0	0	0
8	AC Bus-Pvt.	0	0	0	0	0
9	Rail	362	0	0	0	0
10	Cycle	0	0	0	0	0

Sl. No.	Mode	TL <100	TL 100-150	TL 151-200	TL 201-400	TL >400
11	Walk	0	0	0	0	0
12	Other	0	0	0	0	0
	Total	4580	964	362	0	0

TL – Trip Length*

From the above trip length distribution of passengers and assumptions as Stated above, the potential trips from Cochin and Thiruvananthapuram airport and also the trips from accompanies are provided in **Table 4-59** below.

Table 4-59: Potential Airport Passengers

Location	Daily Pax trips	Daily Pax trips with accompanies
Kochi Airport	1954	4673
Thiruvananthapuram Airport	362	1085
Total	2316	5758

4.9.5 Potential Trips for RoRo

As part of SilverLine, potential for Roll-on Roll-off (RoRo) is also analysed. The data from OD-Survey and secondary data collected from operators, railway parcel offices was analysed to verify the OD data. As the RoRo is for a length of 529.45 Km, the potential traffic is derived based on the following assumptions:-

a) All goods vehicle above 2-Axle was only considered. So, 2-3 Axle trucks, multi-axle vehicles (MAVs) are considered.

b) Goods vehicles (above 2-Axle), with a trip length of 300Km and upto 800Km are only considered. Trip length of above 300km is considered based on Vehicle Operating Cost (VOC) and travel time of truck with or without RoRo. Less than 300 km trip length, it is observed that there will be negligible travel time savings for the truck operator as boarding and alighting time of RoRo is in the range of 1.5 hrs each respectively. The maximum limit of 800Km is assumed based on the trip length and trucks travelling along the project influence area and maxim of upto 100Km at both the ends (from Thiruvananthapuram & from Kasaragod)

c) Trucks with commodities such as building materials, petroleum products, chemical & inflammable items, construction materials and empty and not considered.

The potential traffic for RoRo is provided in the **Table 4-60** below:-

Table 4-60: Potential RoRo traffic – Daily Estimate

Trip Length	TEMPO	LCV	2-3 A	MAV	Total
<50km	1162	1599	453	151	3366
50-200km	1225	2075	704	323	4327
200-300km	81	241	185	153	660
300-600km	71	302	**163**	**127**	662
600-800km	16	70	**67**	**37**	190

Trip Length	TEMPO	LCV	2-3 A	MAV	Total
800-1500km	8	23	15	43	90
>1500km	0	22	21	32	74
Total	**2562**	**4332**	**1609**	**867**	**9369**

4.10 STATED PREFERENCE/ WILLINGNESS TO PAY (WTP) SURVEY

Stated Preference survey was conducted at Airports, major bus terminals, on-board buses and major trains and different class of trains along the proposed SilverLine corridor. The regional bus, train AC, train Non AC and AC bus users were interviewed to appreciate the personal characteristics, travel details, willingness to pay and shift to SilverLine and opinion on preference on 6 hypothetical transport scenarios.

The data was used for development of modal equations for determining likely shift to SilverLine. A total of 1000 responses were collected from different users along the proposed SilverLine corridor. Willingness to Pay survey was carried to understand the user perception, travel characteristics and willingness to shift to SilverLine System. Each Scenario in the questionnaire refers to a set or combination of Travel Cost, Time and Frequency for both SilverLine and the present mode, for an average trip length of 200 km. The six scenarios considered for the study are given in

Table 4-31.

Summary of the responses are presented in **Table** 4-61.

Table 4-61: Scenario Wise Response – WTP Survey

Scenario			Response	Vehicle Category (%)						
Sce. No.	Fare	Frequency		AC Bus	Non AC Bus	Sleeper Class	1st AC	2nd AC	3rd AC	Flight
1	500	30	Definitely Prefer Present Mode	0.4	0.4	0.0	0.0	0.0	0.0	1.2
			Possibly Prefer Present Mode	0.0	0.7	0.0	0.0	0.0	0.0	0.6
			Indifferent	0.0	0.0	0.0	0.0	0.0	0.0	0.6
			Possibly Prefer SilverLine	11.9	28.4	4.6	13.4	0.8	6.8	11.0
			Definitely Prefer SilverLine	**87.7**	**70.5**	**95.4**	**86.6**	**99.2**	**93.2**	**86.6**
			Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
2	500	60	Definitely Prefer Present Mode	0.4	0.4	0.0	1.2	0.0	0.0	1.2

Scenario			Response	Vehicle Category (%)						
Sce. No.	Fare	Frequency		AC Bus	Non AC Bus	Sleeper Class	1st AC	2nd AC	3rd AC	Flight
			Possibly Prefer Present Mode	0.0	0.7	0.0	0.0	0.0	0.0	0.6
			Indifferent	0.0	0.0	0.0	0.0	0.0	0.0	0.6
			Possibly Prefer SilverLine	17.2	39.6	17.4	18.3	3.1	9.4	16.3
			Definitely Prefer SilverLine	**82.4**	**59.4**	**82.6**	**80.5**	**96.9**	**90.6**	**81.4**
			Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
3	**700**	**30**	**Definitely Prefer Present Mode**	7.0	1.8	8.2	9.8	1.6	0.0	4.2
			Possibly Prefer Present Mode	12.3	17.3	22.7	2.4	7.9	6.0	6.0
			Indifferent	0.0	4.0	5.5	0.0	0.8	0.0	4.8
			Possibly Prefer SilverLine	63.1	65.3	50.0	41.5	52.8	48.7	51.8
			Definitely Prefer SilverLine	**17.6**	**11.6**	**13.6**	**46.3**	**37.0**	**45.3**	**33.1**
			Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
4	**700**	**60**	**Definitely Prefer Present Mode**	13.9	9.1	22.9	14.8	3.1	0.9	10.9
			Possibly Prefer Present Mode	14.3	32.4	17.4	25.9	8.7	6.0	8.5
			Indifferent	0.0	9.1	4.6	0.0	0.8	0.0	6.7
			Possibly Prefer SilverLine	61.9	41.8	49.5	33.3	50.4	47.9	43.0
			Definitely Prefer SilverLine	**9.8**	**7.6**	**5.5**	**25.9**	**37.0**	**45.3**	**30.9**
			Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
5	**900**	**30**	**Definitely Prefer Present Mode**	28.4	31.0	41.8	59.4	4.9	16.5	22.6

Scenario			Response	Vehicle Category (%)						
Sce. No.	Fare	Frequency		AC Bus	Non AC Bus	Sleeper Class	1st AC	2nd AC	3rd AC	Flight
			Possibly Prefer Present Mode	53.0	58.6	34.7	10.1	76.4	44.0	43.8
			Indifferent	1.9	4.2	7.1	0.0	2.4	2.8	8.0
			Possibly Prefer SilverLine	15.8	6.1	14.3	27.5	13.8	29.4	19.0
			Definitely Prefer SilverLine	**0.9**	**0.0**	**2.0**	**2.9**	**2.4**	**7.3**	**6.6**
			Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
6	**900**	**60**	**Definitely Prefer Present Mode**	58.2	61.0	60.9	69.2	67.5	48.6	49.2
			Possibly Prefer Present Mode	25.5	34.4	28.3	0.0	16.3	12.8	16.1
			Indifferent	1.4	1.2	2.2	0.0	0.8	1.8	6.5
			Possibly Prefer SilverLine	14.4	3.5	8.7	27.7	13.0	29.4	21.0
			Definitely Prefer SilverLine	**0.5**	**0.0**	**0.0**	**3.1**	**2.4**	**7.3**	**7.3**
			Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

A general trend observed from the data collected by M/s P.K Engineers is that as fare increases willingness to shift to SilverLine decreases and people will prefer present mode. People travelling by Flight and AC class are showing more willingness to shift to SilverLine across all scenarios.

Also at same fare, as frequency decreases people are showing less willingness to shift to SilverLine.

As per the preliminary analysis, the results are not logical. For example, the willingness to shift to SilverLine from Sleeper Class Train is about 95% at a fare of Rs 500 (almost 3 times the current fare of Sleeper Class) and frequency of 30 min. There is a similar trend of respondents showing higher willingness to shift to SilverLine for other Scenarios, which seems not logical.

So, samples were selected for further analysis based on logical assumptions, such as:-

1) Daily travel commuters with monthly income less than INR 20,000/- and INR 10,000/- and Stated to shift for daily commute were removed.
2) The commuters who Stated that at higher fares, willing to shift and at lower fares, not willing to shift were removed. This is because of lack of understating of the scenarios by the commuters.
3) The origin and destination of the commuters which are falling majorly outside the PIA and still Stated to shift were also removed from analysis.

Based on the above assumptions, out of 1100 samples collected from various modes, only 380 samples were shortlisted for further analysis.

4.10.1 Mode Shift Analysis

Stated Preference surveys were conducted to determine willingness to pay, potential mode shift and value of time of various users of SilverLine system. A well-structured format was made describing multiple scenarios to the users under varying parameter ranges. Mode wise binary logit models which give the probability of shifting from existing alternatives to SilverLine were developed using the preferences indicated by the respondents. These models are of the following form.

The purpose of Mode Shift analysis is to determine the probability of shift to SilverLine from various modes.

$$P = \frac{e^{(Gx)}}{(1+ e^{(Gx)})} \quad \text{Where } P = \text{probability of shift, } Gx = \text{generalised cost}$$

$$Gx = \text{Constant} + \alpha\, STT + \beta\, STC + \gamma\, SWT + \lambda\, STR$$

Where,

STT = Savings in Travel Time (Including Access & Dispersal Time)

STC = Savings in Travel cost (including access & egress cost)

SWT = Savings in Waiting time

STR = Savings in number of transfer in the journey

α β γ λ = Parameters to be estimated using SP data and

Constant = constant that explains the unobserved effects

The generalised cost of different modes like Car, Bus and Train are estimated based on the travel cost, travel time of the trips and wait time. The wait time was assumed based on the frequency for all modes.

The parameters of the mode wise logit models were calibrated by employing maximum likelihood method of estimation. The results of calibration for different modes w.r.t SilverLine are provided in the table below. The signs of all the parameters are found to be logical. All the variables that entered the model are found to be statistically significant.

The nagelkerke R square value (a robust goodness-of-fit statistic that varies between 0.6 and 0.8) for all the models is found to be reasonably good.

Table 4-62: Results from Logit Models

Mode	Variable	ASC	Travel Time	Travel Cost	% Correct Predictions	Nagelkerke R Square
1AC	Coefficient	-15.277	-0.147	-0.02	90.8	0.759
2AC	Coefficient	-1.87	-0.026	-0.016	85.4	0.680
3AC	Coefficient	-11.19	-0.108	-0.014	89.6	0.593
SL	Coefficient	-31.632	-0.288	-0.025	92.3	0.812
AC Bus	Coefficient	-4.056	-0.076	-0.021	91.3	0.834
Non-AC Bus	Coefficient	-13.651	-0.491	-0.022	90.5	0.784

The detail output and results from the model is provided in the Volume III – Part 3A: Section 3 - iii.3 Results of Stated Preference Survey Analysis.

In case of car users, for every 25% decrease in savings of travel time and travel cost, there will be a decrease of 10% in the shift to SilverLine. It was observed that, Travel cost is the major factor for the mode choice of car passengers. If there is a decrease of 25% in savings of Travel cost alone, there will be a decrease of 12% in the shift.

In case of Non AC bus users, Travel Time has major impact on mode choice compared to travel cost. If there is a decrease of 25% in the savings of Travel cost and wait time, then there will be a decrease of approximately 6% in the shift from existing mode to SilverLine system.

In case of AC bus users, travel time has major impact on mode choice compared to travel cost. If there is a decrease of 25% in the savings of travel time, then there will be a decrease of approximately 11% in the shift from existing mode to SilverLine system.

The table below shows the probability of shift from various modes and the potential trips in the base year:-

Table 4-63: Probability of Shift to SilverLine

Sl.No.	Class Type	Potential Trips	Prob Shift	Base Trips
1	1 AC	116	24.90%	29
2	2AC	3094	34.20%	1058
3	3AC	15535	38.80%	6028
4	SL	73230	10.30%	7543
5	AC Bus	38639	26.00%	10046
6	Non AC Bus	49803	9.70%	4831
7	Car	158271	12.00%	18993

4.11 ESTIMATED GROWTH RATES

For an efficient proposal, existing and proposed facilities are analysed for future. This covers existing, additional and forecasted commuters for proposed SilverLine, existing and future demand on allied infrastructure such as stations, parking etc., due to proposed facilities.

The expected traffic growth due to a transport infrastructure plays a crucial role in operation planning, station design, commuter facilities based on commuter footfall in that region. Since, there are various independent variables affecting the dependent variables. It becomes a challenge to accurately predict/estimate these growth rates. Many uncertainties are associated with the independent variables which go into the procedure of estimating the growth rates. The uncertainties are in the form of changes in National economy, Government policy, socio-economic conditions of the people, changes in land uses and development of another transportation infrastructures.

Planning of SilverLine and its viability is dependent on the projected traffic. In practice, future traffic growth rate is influenced by numerous parameters. Therefore, while carrying out the traffic forecast, it should be kept in mind that all the parameters are assessed at the macro level of the country's economy. Economic indicators like Per capita Income (PCI), Net State Domestic Product (NSDP), Gross State Domestic Product (GSDP) and District Domestic Product (DDP), population and vehicle registration data are associated with the traffic growth in an Economic Model. Recognizing this, efforts are made to carefully assess all the parameters that help in predicting the traffic demand in future which necessitates realistic estimation of traffic growth rates. For this project traffic growth rates are estimated using Elasticity method.

4.11.1 Approach

Future prospects of project influence area are analysed, while past trend in growth is also considered during forecasting traffic for the hub. For long term forecasting elasticity approach of growth rate estimation is used. The approach included following steps:-

1. Potential of Growth of various vehicle categories (car), passengers (in case of rail passengers), and earnings (in case of bus) are separately assessed based on its probable market share in expected multi-modal travel characteristics.
2. Per Capita Income (PCI) of Kerala is considered for determining growth rate of private vehicles like cars and other public transport modes such as bus and rail passengers etc.
3. Regional Economic factors such as Growth in Gross State Domestic Product (GSDP) and Net State Domestic Product (NSDP) is also studied and checked for determining growth rate of different types of rail and bus passengers and also goods traffic.

4.11.2 Growth Rate in Regional Economies

Growth of traffic on the hub depends on existing development and future growth prospects of the connecting regions. The time series data of economic indicators at constant (2011-12) prices for the project influence area derived from the published data by Department of statistics, Government of Kerala are presented below.

Table 4-64 Growth Rate in Regional Economies

Year	Gross State Domestic Product (Rupee in lakhs) @ 2011-12 prices	Net State Domestic Product (Rs. lakhs) @ 2011-12 prices	Per Capita Income (Rs.)
2011-12	36404789	32802112	97912
2012-13	38769346	34861581	103551
2013-14	40278133	36470677	107846
2014-15	41995555	38213426	112444
2015-16	45121002	41115015	120387
2016-17	47928990	43839422	127729
2017-18(Q)	51369589	46988233	136225
CAGR (2011-18)	5.91%	6.17%	5.66%

4.11.3 Transport Demand Elasticity

Since, demand changes are usually because of shifts in the pattern of economic activities in the influence area it is not appropriate to use past traffic growth trend to extend in near future. Therefore, elasticity approach is used for future traffic forecasting which takes into account the elasticity of transport demand and probable pattern of future growth of the economy.

The Elasticity Method relates traffic growth due to changes in the related economic parameters. This method studies, in an appropriate perspective, the changes in observed past traffic volumes in the context of changes in relevant economic indicators in the Project Influence Area (PIA), to which it was closely related in the past. Such parameters include Net State Domestic Product (NSDP), income accruing to the major sectors of the economy, etc. This method takes into account not only the past growth of the major economic indicators, but also the future perspective. The elasticity based econometric model could be derived in the following form:

$\text{Log}_e P = A0 + A1\ \text{Log}_e(EI)$

Where:

P = traffic volume;

EI = Economic Indicator;

A0 = Regression constant;

A1 = Regression co-efficient (Elasticity Index).

Elasticity values for each mode is estimated using the past vehicle registration data and the growth of PIA NSDP. The elasticity's obtained are as presented below.

Table 4-65 Weighted Elasticity Coefficient- Other Vehicles

Weighted Elasticity Coefficient						
Vehicle Type	Car	Taxi	Bus - stage	Rail	Bus - Contract	Car + Taxi
GSDP	2.18	-1.20	1.95	1.53	-2.46	1.92
NSDP	2.08	-2.26	1.85	0.91	-2.34	1.83
PCI	2.26	-1.23	2.01	1.59	-2.55	1.99

The above indicated elasticities for bus and car was observed to be very high and for taxi and contract carriage buses, it was in negative. So, car and taxi vehicle registration data was combined to arrive at revised elasticity. Similarly for bus, stage carriage and contract carriage bus registration data was combined and it was also observed in both cases that the values were on higher side and un-realistic. The higher elasticity values was observed due to the source of the data selected such as vehicle registration data.

So, for car and taxi, data from toll plaza was used (for three years from Paliyekara and Kubalam toll plaza on NH 544 and NH 66 respectively) and was observed with a growth rate of 5.9%. Similarly for bus, the yearly earnings from bus operations received from KSRTC was used for arriving at revised elasticity. The weighted elasticity coefficients adopted for the study are provided in the **Table 4-66** below:-

Table 4-66 Adopted Weighted Elasticity Coeff. - Bus, Rail and Pvt. Veh.

Vehicle Type	Bus	Rail	Car & Taxi
GSDP	0.91	1.53	1.30
NSDP	0.87	0.91	1.30
PCI	0.94	1.59	1.40

Based on the above elasticity and the GDP growth rate forecast for India, growth rates are estimated for each mode and class. For this, scenarios were created and growth rates for each mode was assumed based on the various parameters of the scenarios. The scenarios and the parameters along with their considerations and assumptions are provided in the subsequent sections.

4.11.4 Scenario Development

The patronage for any regional transit system can vary based on multiple factors as there are external factors which impacts the patronage. So, understanding of the best and the worst cases related to ridership is a necessity. For this study, four different scenarios are developed based on four major parameters. The scenarios are optimistic, realistic, business-as-usual (BAU) or Do-nothing and pessimistic scenarios. The assumptions and

considerations for each scenarios varies based on the parameters such as infrastructure developments, India's and Kerala's GDP forecast, additional traffic, and changes in probability of shift from potential trips.

The scenarios and parameters are detailed out in the subsequent sections.

4.11.4.1 Pessimistic Scenario:

In this scenario, it is assumed that the infrastructure development, trip pattern and growth estimates may slow down in the future years. The assumptions and considerations are as follows:-

1) No additional infrastructure developments and employment generation along the corridor.
2) No scope of additional trips from any external developments are considered.
3) The GDP growth rate shall be minimal and similar to present condition and shall grow from 4.8% to 5.5% and moderated downwards for the future years. The GDP growth assumed are as follows:-

Table 4-67: India's GDP – Pessimistic Scenario

Duration	Pessimistic
2016-20	4.8%
2021-25	5.5%
2026-30	5.0%
2031-35	4.5%
2036-40	3.5%
2041-45	3.0%
2046-50	2.5%

4) Potential Trips: the potential trips estimated for modes, car, taxi and rail will remain similar to as estimated and for bus, only AC buses and express buses will be considered.

4.11.4.2 Business As Usual – Do-nothing scenario:

In this scenario, it is assumed that the present conditions in terms of infrastructure, trip pattern and growth estimates will prevail in the future years. The assumptions and considerations are as follows:-

1) No additional infrastructure developments and employment generation along the corridor: Only existing infrastructure project such as 4-laning and road improvement projects which are under construction stage will be completed.
2) No organised feeder service for SilverLine: the feeder service will be operated by IPTs and other private bus operators based on demand and may not be organised. The feeder will form part of the main transit on its own as demand increases. Also, no integration of feeder is expected with the SilverLine system.

3) The GDP forecast shall be minimal and similar to present condition and shall grow from 4.8% to 6% and moderated downwards for the future years. The GDP growth assumed are as follows:-

Table 4-68: India's GDP – BAU

Duration	Business as Usual
2016-20	4.8%
2021-25	6.0%
2026-30	5.0%
2031-35	4.5%
2036-40	3.5%
2041-45	3.0%
2046-50	2.5%

4) Potential Trips: the potential trips estimated for modes, car, taxi and rail will remain similar to estimated and for bus, only AC buses and express buses will be considered.

4.11.4.3 Realistic Scenario

In this scenario, developments in infrastructure sector, employment generation and scope for additional traffic is considered. All the developments and assumptions are achievable without much externalities. The assumptions and considerations are as follows:-

1) All the existing and proposed road improvement projects will be completed along with other developments in the IT and employment sector.
2) Additional traffic from two major sources such as by introduction of feeder service and developments through Transit Orient Development (TOD) is considered. Organised feeder will be operated by K-Rail or managed by K-Rail by integrating with departure and arrival timings of SilverLine trains at stations. Regarding TOD, additional land around the stations will be developed as TOD and a percent will be considered as regional trips shifting to SilverLine. In all the cases, only 50% of the actual trips will be considered.
3) The GDP forecast is expected to grow from the present condition up to a rate of 6.5% and moderated downwards. The growth rates are assumed based on the economic survey & IMF forecast of 6.1% till 2021-22. The GDP growth assumed for realistic scenarios are as follows:-

Table 4-69: India's GDP – Realistic Scenario

Duration	Realistic
2016-20	5.0%
2021-25	6.5%
2026-30	6.0%

Duration	Realistic
2031-35	5.0%
2036-40	4.0%
2041-45	3.0%
2046-50	2.5%

4) Potential Trips: the potential trips estimated for modes, car, taxi and rail will remain similar as estimated and for bus, AC buses, express buses and 50% of the potential trips from Super-Fast Passenger bus is also considered.

4.11.4.4 Optimistic Scenario

In this scenario, developments in infrastructure sector, employment generation and additional traffic is considered. All the developments and assumptions are assumed at a higher rate based on the various vision document of Government of Kerala and Government of India. The assumptions and considerations are as follows:-

1) It is assumed that all highways (NHs & SHs) along the east-west direction in Kerala shall be widened and improved to next level. This shall improve accessibility with catchments on the eastern districts.
2) Additional traffic from two major sources such as by introduction of feeder service and developments through Transit Orient Development (TOD) is considered. In this scenario, 100% of the trips generated due to introduction of feeder and TOD development is considered.
3) The GDP forecast is expected to grow from the present condition up to a rate of 7.5% and moderated downwards. The higher growth rates are assumed based on the following:-
    a. For achieving GoI's vison of 5 trillion economy by 2025, the GDP may have to grow at a rate of minimum 7.5% from 2020.
    b. The Kerala Perspective plan 2030, also envisage a per capita GSDP to grow at 7.5% (compounded annual growth rate) till 2030.
4) The GDP growth assumed for optimistic scenarios are as follows:-

Table 4-70: India's GDP – Optimistic Scenario

Duration	Optimistic
2016-20	6.0%
2021-25	7.5%
2026-30	7.0%
2031-35	6.5%
2036-40	4.5%
2041-45	3.0%
2046-50	2.5%

5) Potential Trips: the potential trips estimated for modes, car, taxi is assumed with 5% increase from estimated. The potential trips from rail will remain similar as estimated and for bus, AC buses, express buses and 100% of the potential trips from Super-Fast Passenger bus is also considered.

The summary of all the scenario is provided below.

Table 4-71: Summary of India's GDP – All Scenarios

Duration	Pessimistic	Business as Usual	Realistic	Optimistic
2016-20	4.8%	4.8%	5.0%	6.0%
2021-25	5.5%	6.0%	6.5%	7.5%
2026-30	5.0%	5.0%	6.0%	7.0%
2031-35	4.5%	4.5%	5.0%	6.5%
2036-40	3.5%	3.5%	4.0%	4.5%
2041-45	3.0%	3.0%	3.0%	3.0%
2046-50	2.5%	2.5%	2.5%	2.5%

4.11.5 Adopted Growth Rates (Passenger) – Scenario-wise

The adopted growth rates for the modes – rail, bus and car based on each scenario are provided in the tables below:-

Table 4-72 Scenario-wise Adopted Growth Rates – Pessimistic and BAU

Scenario	Pessimistic			Business as Usual		
Duration	Rail	Bus	Car	Rail	Bus	Car
2016-2020	3.5%	3.6%	4.6%	3.5%	3.6%	4.6%
2021-2025	4.0%	3.7%	4.7%	4.4%	4.1%	5.2%
2026-2030	3.6%	3.0%	4.3%	3.6%	3.0%	4.3%
2031-2035	2.9%	2.2%	3.2%	2.9%	2.2%	3.2%
2036-2040	2.3%	1.7%	2.2%	2.3%	1.7%	2.2%
2041-2051	1.8%	1.0%	1.9%	1.8%	1.0%	1.9%
Average	**3.0%**	**2.5%**	**3.5%**	**3.1%**	**2.6%**	**3.6%**

Table 4-73 Scenario-wise Adopted Growth Rates – Realistic and Optimistic

Scenario	Realistic			Optimistic		
Duration	Rail	Bus	Car	Rail	Bus	Car
2016-2020	3.6%	3.8%	5.6%	4.4%	4.6%	6.7%
2021-2025	4.7%	4.9%	5.8%	5.4%	5.7%	8.4%
2026-2030	4.4%	4.1%	5.4%	5.1%	5.3%	5.6%
2031-2035	3.3%	2.7%	4.0%	4.7%	4.9%	4.7%
2036-2040	2.6%	2.2%	2.9%	3.3%	3.4%	3.2%
2041-2051	1.8%	1.1%	1.9%	2.2%	2.3%	1.9%

Scenario	Realistic			Optimistic		
Duration	Rail	Bus	Car	Rail	Bus	Car
Average	3.4%	3.1%	4.3%	4.2%	4.4%	5.1%

From the above tables, in all scenarios, the growth rates for the duration is adopted till 2051 instead of the growth rates provided in duration 2041-2051. This is based on the other studies in which, all the DPR has used growth rates near to 2% for the FY 25 to FY 30.

For the airport trips, the growth rates were estimated based on the linear trend of passenger traffic handled at airports, which are in the range of 1.8% to 1.9% annual growth rates. The same is applied to airport trips.

The above growth rates were applied to the base trips arrived based on the probability of shift and the patronage for SilverLine is estimated for each of the scenarios. The daily ridership from the commissioning year to the horizon year is estimated and generated traffic from other sources such as introduction of feeder, TOD/developmental traffic are also to be combined to arrive at the final daily ridership.

4.11.6 Adopted Growth Rates for RoRo

The data used for forecast of RoRo was vehicle registration data and also toll data from two tolls. The growth rates for RoRo is estimated based on the India GDP and Kerala GSDP and the elasticity coefficient observed is 0.55. The coefficient was in the logical range and was adopted for traffic forecast. The adopted growth rates for RoRo is provided in the table below:-

Table 4-74 Adopted growth rates for RoRo

Growth Rates	Truck
2016-2020	2.00%
2021-2025	2.60%
2026-2030	2.40%
2031-2035	2.00%
2036-2040	1.60%
2041-2045	1.20%
2046-2052	1.00%

4.11.7 Developmental Traffic – Trips due to TOD

Developmental traffic is that which would be generated, over and above normal growth, because of new developments in the immediate influence area of the proposed SilverLine stations and corridor. This type of developmental traffic is known as Transit Oriented Development (TOD) in which catchments around the Stations would be developed.

It is proposed to acquire land for Transit Oriented Development around the SilverLine stations. TOD is and urban concept and would generate mostly trips within the city. But, it is also expected to generate few percentage of regional trips based on type of

developments. The duplication impact of TOD in future forecasting has been removed while making forecasts. The major assumptions for arriving at traffic are as follows:-

a) The catchment is assumed to be 500m radius of land around each station and the TOD details are as provided in the chapter 16.
b) It is also assumed that the actual development is 30% of the proposed developments.
c) The FAR is assumed to be 4
d) Assumed land use break-up area for development:-

Table 4-75: Land use mix- TOD

Land use Mix	% Share
Office	**40.0%**
Commercial	**50.0%**
Retail	*70.0%*
Hotel (Mixed land use)	*20.0%*
Service Apartment	*10.0%*
Residential	**10.0%**
Total Area	**100.0%**

e) The modal composition of trips: the modal share is assumed based on the modal distribution in Kochi.

Table 4-76: Modal composition - TOD

Mode	Office
Two Wheeler	26.0%
Car	10.0%
Taxi	0.0%
Private	**36.0%**
Auto	6.0%
Share Auto	1.0%
IPT (Intermediate Para Transport)	**7.0%**
City Bus	2.0%
Cycle	3.0%
Cycle Rickshaw	0.0%
Walk	12.0%
NMT & Walk	**15.0%**
MRTS	10.0%
Bus	30.0%
PT (Public Transport)	**42.0%**
Total	**100.0%**

Source: CMP for Greater Cochin Region, KMRL 2016

f) The trip rates are assumed from Feasibility study of Surat multimodal integration study by IRSDC in 2017 for the traffic impact assessment from TOD:

Table 4-77: Trip rates - TOD

Type of Land use	Trip Rate Per 1000 Sq.ft
Office	19.56
Residential	13.92
Retail	38.34

Based on the above assumptions, the traffic generated based on the land use accounts for approximately ~3267 regional trips per days based on above assumptions. This accounts for ~5% of the total trips generated and in optimistic scenario, 10% of the trips are considered as out of the 10 major stations identified for TOD, all stations are proposed to be developed with TOD concept.

4.11.8 Additional Trips due To Introduction of City Feeder Service

Trips due to introduction of organised feeder service integrating with SilverLine timings and well connected with nearest city centre and settlement areas are also considered. The approach used for estimation of additional trips are as follows:-

a) When feeder is introduced, it is considered as increase in length of the transit. The spread of the transit also increase which improves the first and last mile connectivity.
b) The study by climatrans - rapid assessment of travel demand model for delhi, RRTS study by NCRTC, and CMP for Puducherry, Nagpur, Lucknow and various other study indicates that as the transit length and spread increases, it attracts additional 10-12% of trips.
c) In this study, a hypothetical approach using existing waiting time as travel time savings was adopted. The modal shift based on revised utility equation was generated and applied.
d) The waiting time is considered as travel time savings when feeder service is introduced. This waiting time is additional and do not have any correlation with waiting adopted for modal shift using the binary logit model equation for the modal shift provided in 4.10.1.
e) The observed and adopted waiting time from the traffic survey are as follows:-

Table 4-78: Adopted Travel Time savings due to City Feeder

Mode	Waiting Time (min)	Adopted WT (min)
AC Train	7.3	6.5
SL	36.9	30.0
AC Bus	13.7	12.0
Non-AC Bus	11.0	10.0

f) With the revised travel time savings, revised utility/probability of shift is estimated. The old and new probability of shift and potential trips are provided in table below:-

Table 4-79 Revised trips based on travel time savings

Sl.No.	Modes	Potential Trips	Shift as per SP Analysis	Total Trips	New Mode Shift	New Base Trips
1	1 AC	116	24.90%	29	26.35%	31
2	2AC	3094	34.20%	1058	34.76%	1075
3	3AC	15535	38.80%	6028	41.40%	6432
4	SL	73230	10.30%	7543	15.09%	11048
5	AC Bus	38639	26.00%	10046	27.75%	10723
6	Non AC Bus	49803	9.70%	4831	12.10%	6026
7	Car	158271	14.00%	22158	14.00%	22158
Total				51692		57493

The above trips accounts for 11.22% increase in trips if feeder service is introduced. But near to 50% trips are considered in realistic scenario due to the assumption that only three major cities – Kochi, Thiruvananthapuram and Kozhikode will be implemented with higher order feeder such as MRTS/LRT/Metrolite etc.

4.11.9 Estimated Daily Ridership

Based on the estimated growth rates for each scenario and inclusion of additional traffic based on assumptions and consideration, the brief of estimated ridership for the forecasted years and for different scenarios, and parameters are provided in the tables below.

Table 4-80 Estimated Ridership – Pessimistic Scenario

Year	Rail	Bus	Car	Total Daily Ridership (from Existing modes)	Total with Airport trips	Total with Airport trips & Feeder	Total with Airport trips, Feeder & TOD
2025-26	11329	15655	25041	52025	54583	-	-
2029-30	13066	17645	29643	60354	63069	-	-
2041-42	17835	22265	41255	81355	84567	-	-
2052-53	21620	24897	50824	97341	101085	-	-

Table 4-81 Estimated Ridership – Business as Usual Scenario

Year	Rail	Bus	Car	Total Daily Ridership (from Existing modes)	Total with Airport trips	Total with Airport trips & Feeder	Total with Airport trips, Feeder & TOD
2025-26	18776	18798	25559	63133	65724	-	-
2029-30	21656	21188	30255	73099	75892	-	-
2041-42	29568	26736	42106	98410	101869	-	-
2052-53	35841	29895	51870	117606	121770	-	-

Table 4-82 Estimated Ridership – Realistic Scenario

Year	Rail	Bus	Car	Total Daily Ridership (from Existing modes)	Total with Airport trips	Total with Airport trips & Feeder	Total with Airport trips, Feeder & TOD
2025-26	19133	19583	26623	65339	71779	76667	79934
2029-30	22695	22954	32829	78478	85421	91150	94672
2041-42	32212	30711	49392	112315	120916	128580	132944
2052-53	39048	34767	60850	134665	145018	153694	158946

Table 4-83 Estimated Ridership – Optimistic Scenario

Year	Rail	Bus	Car	Total Daily Ridership (from Existing modes)	Total with Airport trips	Total with Airport trips & Feeder	Total with Airport trips, Feeder & TOD
2025-26	19944	26430	42986	89360	95800	105828	114764
2029-30	24320	32510	53421	110251	117194	129529	139164
2041-42	38625	52694	84649	175968	184569	204562	216498
2052-53	48965	67502	104283	220750	231103	256713	271080

The summary of the daily ridership estimate including airport trips, additional traffic due to introduction of city feeder service and traffic from TOD is provided in table below:-

Table 4-84 Daily Ridership Estimate - Summary

Scenario	Pessimistic	Business as Usual	Realistic	Optimistic
2025-26	54583	65724	**79934**	114764
2029-30	63069	75892	**94672**	139164
2041-42	84567	101869	**132944**	216498
2052-53	101085	121770	**158946**	271080

From the above table it is observed that the daily ridership varies between ~54,000 to ~1,14,000 in the commissioning year and ~1,01,000 to ~2,71,000 in the horizon year for each of the scenarios. Based on the approach and initiatives taken by the K-Rail such as discussion with representatives of Airport Authority, TOD land bank project (already under tendering stage), strategies adopted to bring last-mile connectivity, it is expected that the ridership may reach as provided in the realistic scenario. So, for further analysis and estimations of rolling stock, station design etc., the daily ridership estimate of the realistic scenario is considered.

4.11.10 Station-wise Loading: Sectional Load

Station wise boarding and alighting of passengers for the proposed SilverLine, between Thiruvananthapuram and Kasaragod, is estimated considering the probability of shift from the respective mode of transport (i.e. Bus, Train & Car) and the potential traffic estimated based on Stated preference survey and OD survey.

The daily boarding and alighting at SilverLine stations and the section load for horizon years 2025-26, 2029-30, 2041-42 and 2052-53 are presented in table 4-86 to table 4-87. Peak hour boarding and Alighting and Section Load (PHPDT) summary is presented in table 4-88 and table 4-89.

Table 4-85 Daily Boarding and Alighting (inc. Thiruvananthapuram Airport)

Station Name	Boarding (Daily)				Alighting (Daily)			
	2025-26	2029-30	2041-42	2052-53	2025-26	2029-30	2041-42	2052-53
Thiruvananthapuram Airport	710	740	970	1,160	650	680	890	1,100
Thiruvananthapuram	16,100	20,430	29,030	34,700	15,010	18,970	26,950	32,200
Kollam	4,820	5,790	8,390	10,040	4,740	5,690	8,230	9,900
Chengannur	2,530	3,080	4,550	5,500	2,470	3,000	4,430	5,400
Kottayam	5,080	6,130	8,850	10,560	5,140	6,200	8,930	10,700
Ernakulam	14,400	17,340	25,010	29,900	14,240	17,230	24,790	29,600
Kochi Airport	3,480	3,830	5,410	6,440	3,460	3,830	5,400	6,400
Thrissur	8,190	9,380	11,730	14,020	8,320	9,580	12,200	14,600
Tirur	2,700	2,480	3,660	4,390	2,610	2,440	3,600	4,300
Kozhikode	10,790	12,130	15,040	17,920	11,430	12,810	15,820	18,800
Kannur	7,920	9,520	14,150	16,930	8,420	10,110	15,050	18,000
Kasargod	3,070	3,700	5,990	7,190	3,330	4,010	6,490	7,800
Total	**79,800**	**93,800**	**131,800**	**157,600**	**79,150**	**93,850**	**131,900**	**157,700**

From the above indicated line loadings, it was decided by the KRDCL Board to construct the Thiruvananthapuram Airport station at later stage based on the future demand. However, the proposed LRT/Metrolite for Thiruvananthapuram city may also be used to bring airport passengers to the Thiruvananthapuram SilverLine station or other systems such as Automated People Movers (APMs), Personalised Rapid transit (PRT – PODS) etc., may also be studied.

Table 4-86 Daily Ridership - Boarding and Alighting

Station Name	Boarding (Daily)				Alighting (Daily)			
	2025-26	2029-30	2041-42	2052-53	2025-26	2029-30	2041-42	2052-53
Thiruvananthapuram	16,030	20,490	29,040	34,720	14,800	18,910	26,800	32,000
Kollam	5,210	5,790	8,710	10,410	5,160	5,690	8,570	10,300
Chengannur	2,530	3,080	5,190	6,270	2,470	3,000	5,120	6,200
Kottayam	5,090	6,130	8,850	10,560	5,150	6,200	8,930	10,700
Ernakulam	14,850	18,020	25,010	29,900	14,730	17,960	24,790	29,600
Kochi Airport	3,490	3,830	5,410	6,440	3,470	3,830	5,400	6,400

Station Name	Boarding (Daily)				Alighting (Daily)			
	2025-26	2029-30	2041-42	2052-53	2025-26	2029-30	2041-42	2052-53
Thrissur	8,200	9,380	11,730	14,020	8,330	9,580	12,200	14,600
Tirur	2,700	2,480	3,660	4,390	2,620	2,440	3,600	4,300
Kozhikode	10,810	12,130	15,040	17,920	11,440	12,810	15,820	18,800
Kannur	7,930	9,520	14,150	16,930	8,430	10,110	15,050	18,000
Kasargod	3,080	3,700	5,990	7,190	3,340	4,010	6,490	7,800
Total	**79,900**	**94,550**	**132,800**	**158,750**	**79,950**	**94,550**	**132,750**	**158,700**

Table 4-87 Daily Ridership - Sectional Load

Station Name	Forward				Reverse			
	2025-26	2029-30	2041-42	2052-53	2025-26	2029-30	2041-42	2052-53
Thiruvananthapuram	0	0	0	0	14,800	18,910	26,800	32,050
Kollam	16,030	20,490	29,040	34,720	15,380	20,050	28,420	33,970
Chengannur	16,660	21,720	30,790	36,800	16,140	21,010	29,230	34,970
Kottayam	17,480	22,760	31,670	37,880	15,440	20,160	28,260	33,790
Ernakulam	16,730	21,830	30,610	36,600	16,860	20,890	30,940	37,010
Kochi Airport	18,270	22,630	33,520	40,090	17,130	20,940	31,030	37,090
Thrissur	18,560	22,680	33,620	40,180	15,590	18,560	25,320	30,260
Tirur	16,890	20,110	27,430	32,780	16,640	19,050	26,030	31,080
Kozhikode	18,020	20,640	28,200	33,660	9,040	10,820	16,690	19,970
Kannur	9,790	11,720	18,080	21,640	3,080	3,700	5,990	7,190
Kasargod	3,340	4,010	6,490	7,790	0	0	0	0
Total	**18,560**	**22,760**	**33,620**	**40,180**	**17,130**	**21,010**	**31,030**	**37,090**

Table 4-88 Peak Hour - Boarding and Alighting

Station Name	Boarding (Peak Hour)				Alighting (Peak Hour)			
	2025-26	2029-30	2041-42	2052-53	2025-26	2029-30	2041-42	2052-53
Thiruvananthapuram	1,080	1,380	1,950	2,330	990	1,270	1,800	2,150
Kollam	380	420	630	750	370	410	620	740

Station Name	Boarding (Peak Hour)				Alighting (Peak Hour)			
	2025-26	2029-30	2041-42	2052-53	2025-26	2029-30	2041-42	2052-53
Chengannur	200	250	420	510	200	240	410	500
Kottayam	360	430	630	750	360	440	630	760
Ernakulam	1,170	1,420	1,970	2,350	1,160	1,410	1,950	2,330
Kochi Airport	270	300	430	510	270	300	420	500
Thrissur	600	690	860	1,030	610	700	890	1,070
Tirur	170	160	230	280	170	160	230	280
Kozhikode	760	850	1,060	1,260	800	900	1,110	1,320
Kannur	590	710	1,050	1,260	620	750	1,120	1,330
Kasargod	250	300	490	580	270	330	530	630
Total	**5,830**	**6,910**	**9,720**	**11,610**	**5,820**	**6,910**	**9,710**	**11,610**

Table 4-89 Peak Hour - Sectional Load

Station Name	Forward				Reverse			
	2025-26	2029-30	2041-42	2052-53	2025-26	2029-30	2041-42	2052-53
Thiruvananthapuram	0	0	0	0	990	1,270	1,800	2,150
Kollam	1,160	1,480	2,090	2,500	1,110	1,440	2,050	2,450
Chengannur	1,350	1,750	2,490	2,970	1,300	1,700	2,360	2,830
Kottayam	1,240	1,610	2,240	2,680	1,090	1,420	2,000	2,390
Ernakulam	1,320	1,720	2,410	2,880	1,330	1,640	2,430	2,910
Kochi Airport	1,440	1,780	2,640	3,160	1,350	1,650	2,440	2,920
Thrissur	1,360	1,660	2,460	2,950	1,140	1,360	1,860	2,220
Tirur	1,080	1,290	1,760	2,100	1,070	1,220	1,670	2,000
Kozhikode	1,270	1,450	1,980	2,370	640	760	1,170	1,400
Kannur	730	870	1,340	1,600	230	270	440	530
Kasargod	270	330	530	630	0	0	0	0
Maximum Section Load (PHPDT)	**1,440**	**1,780**	**2,640**	**3,160**	**1,350**	**1,700**	**2,440**	**2,920**

4.12 FARE SENSITIVITY ANALYSIS

Fare sensitivity analysis is carried out to identify the indicate fare for the proposed SilverLine and not for fare box revenue estimation. It is carried out for the base year and commissioning year 2025-26, considering different fares (i.e. from Rs 1 per km to Rs 8 per km) for SilverLine without cost escalation and for the forecasted traffic of 2025-26. Daily ridership for each fare was estimated and corresponding annual fare revenue was calculated. The slab which provide maximum revenue and optimum ridership was considered as the selected fare slab.

The fare was set based on the existing rail and bus fares. The fares are provided in table below:-

Table 4-90 Existing Rail Fares

Sl. No	Class	Fare (in Rs for 200KM)	Per Km (Rs.)
1	1AC	1047	5.24
2	2AC	613	3.07
3	3AC	428	2.14
4	CC	278	1.39
5	SL	120	0.60

Source: Ministry of Railways, 2019

Table 4-91 Existing Bus Fares

Sl. No	Class	Fare (in Rs for 200KM)*	Per Km
1	Volvo	290	1.45
2	Other AC	240	1.20
3	Super Del.	200	1.00
4	Super FP	156	0.78
5	FP	150	0.75

Source: KSRTC, 2019

The per Km fare for private vehicle was observed to be Rs. 8.78 Km. This is based on the IRC SP 30-2009. The private taxi fares are in the range of INR 14/Km. The air fares between Kochi and Trivandrum is in the range of INR 2200/- to INR 4500/- and for Trivandrum to Kozhikode, it is in the range of INR 3500/-.

Average trip length (weighted average of car, rail and bus) of SilverLine, for the commissioning year 2025-26 is considered as 200 km. This is based on the weighted average of trip length of rail, bus and car. The weightage was based on the type of trips selected as potential trips from respective mode. As stated earlier, for rail-based, all trips was considered; while for bus only trips from AC buses, express bus and 50% of super-fast passenger was considered. In case of cars, all the trips which were above 100 Km trip length and within a buffer of 15Km within PIA was considered.

From the trip length frequency distribution and based on the above, the weights for Rail was 69%, Bus 23% and Car was observed to be 8% and average trip length for rail trips

– 202 Km, bus trips – 185Km and Car trips – 56 Km. The weighted average was observed to be 194.56 Km and for future estimation, was rounded off to 200 Km.

The willingness to pay survey also indicates an increase of fare by 1.25 and 1.5 times by approximately 42% AC class passengers and 7% of the sleeper class passengers respectively. Similarly by 16% of non-ac bus users also preferred 1.5 times and 39% of ac bus users by 1.25 times.

Comparison of annual fare revenue and daily ridership for different fares is shown in **Table 4-92** and **Figure 4-82**.

Table 4-92 Fare Sensitivity

Fare of SILVERLINE (Rs/Km)	Daily Rider Ship (000's)	Annual Fare revenue (Rs Cr)
1	137,863	1006
1.5	121,126	1326
2	103,124	1506
2.75	**79,934**	**1605**
3	69,933	1532
3.5	55,291	1413
4	39,717	1160
5	30,527	1114
6	24,979	1094
8	17,215	1005

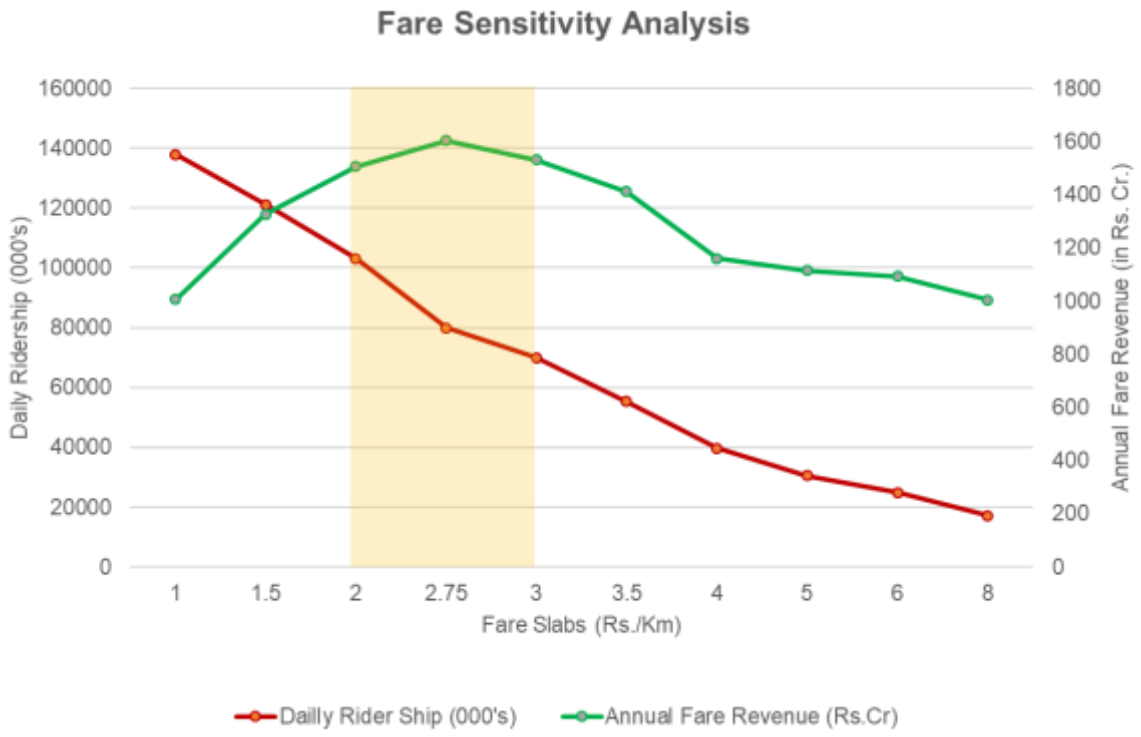


Figure 4-82 Fare Sensitivity Analysis

From the figure, it is observed that maximum fare revenue corresponds to a fare of Rs 2.50 – Rs 3.00 per km. Though the optimum fare for SilverLine is around Rs 2.75 per km, considering the higher ridership at lower fares, the Government/ Authorities may finalise appropriate fare so that the system is effectively utilised to its full capacity.

4.13 TRAVEL DEMAND FORECAST FOR RORO

The traffic forecast for RORO service, in terms of number of trucks (2-Axle and above) based on the adopted growth rates are provided in the table below:-

Table 4-93 Estimated Daily Traffic for RoRo

Year	Estimated Daily Trucks (in No.s)
2025-26	457
2029-30	502
2041-42	620
2052-53	700

From the above figures, based on the operation plan, it is observed that maximum trucks that can be carried by RORO without impacting the passenger operations are 480 per day. So, from 2029, the trucks expected in RORO is capped at 480 till the horizon year.

4.14 ADDITIONAL TRAFFIC SURVEYS

As part of the study, evaluation of different options that could be considered for enhancement of ridership and better utilisation of SilverLine facilities has been undertaken. These are based on the various factors and options considered by other rail operators in India and abroad. Out of the above options, feasibility of operating tourist trains, sleeper trains, restaurant car in trains and feasibility of operating aggregator stations. The traffic surveys were conducted in the month of December 2019 and January 2020 and the results from the analysis are provided in subsequent sections.

4.14.1 Demand Assessment for Operating Tourist Trains

The tourism statistics published by the department of Tourism, Government of Kerala indicates that, there is potential for operating tourist trains in terms of the favourite locations and its proximity to the SilverLine alignment. Out of the top 10 locations visited by the international tourist, 8 locations are along the proposed SilverLine alignment. The corridor and the statistical data is provided in **Figure 4-83** below:-

Sl. No.	Destination	No. of Tourists	Within PIA (Y/N)
1	Kochi City	236870	Yes
2	Kovalam	142914	Yes
3	Fort Kochi	115482	Yes
4	Varkala	103602	Yes
5	Alappuzha	74621	Yes
6	Thiruvananthapuram	64014	Yes
7	Maradu	46034	Yes
8	Kumarakom	35975	Yes
9	Munnar	24293	No
10	Thekkady	19537	No

Source: Kerala Tourism Statistics - 2018

Figure 4-83 Top locations visited by International tourists

The details related to the present trip of the tourists and their willingness to shift to SilverLine Tourist Train were collected through the traffic survey conducted at Thiruvananthapuram, Kochi and Allepy. The information collected includes places visited (in the sequence), landing point, main mode of travel, total cost of the Tour Package. The samples selected were extrapolated to the international and domestic tourist arrival data to arrive at yearly tourist.

The modal distribution of international and domestic tourist is provided in the **Figure 4-84** below:-

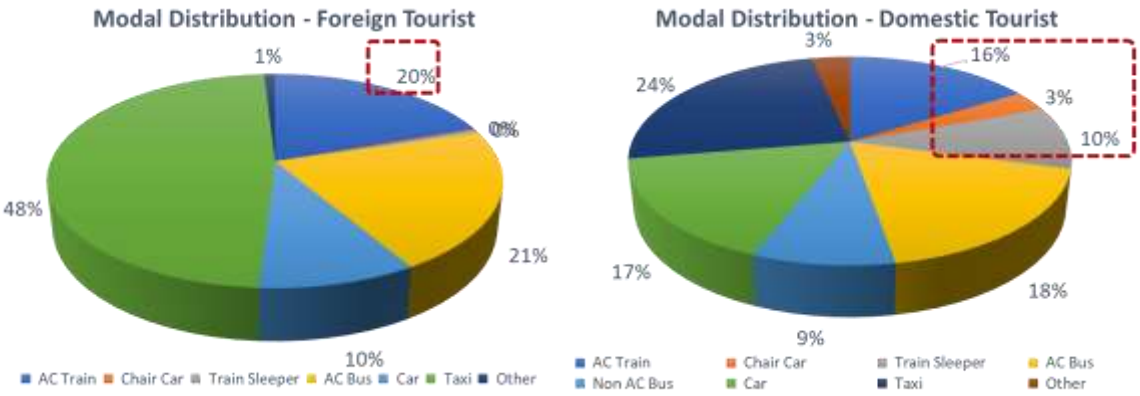


Figure 4-84 Modal Distribution - Tourists

From the above figure, it is observed that 20% of the international tourist and 29% of the domestic tourist uses train as their main mode of travel within Kerala. They are potential trips when only mode is considered.

If affordability is to be considered, then the potential trips may reduce as the tourist trains are proposed to be operated in the same Indian Railways Tourist train model (on lease

model by concerned STC and IRCTC). In this regard, distribution of tourist on the basis of income was also conducted and presented in figure given below.

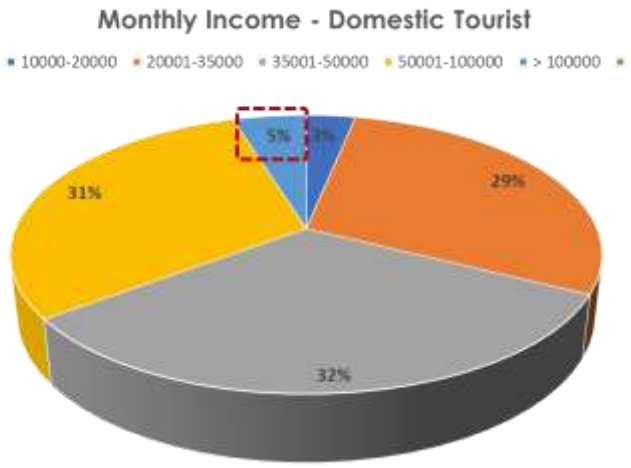


Figure 4-85 Income-wise distribution of Tourists

Income-wise distribution indicates that only 5% of the domestic tourist are above monthly income range of INR 1 lakh and are willing to pay only 2.5 times the existing fare. This shift the focus to the international tourist as they shall be the main target user group when tourist trains are considered. The income distribution of international tourist indicates that more than 48% of the international tourist have monthly income more than $2000/- (two thousand dollars).

Based on the above results and willingness to shift to SilverLine, the potential trips from international and domestic tourist are provided in the **Table 4-94** below:-

Table 4-94 Potential trips – Yearly Tourist

Sl. No	Mode	Domestic	International	Total
1	AC Train	2207	29090	31297
2	Chair Car	403	541	944
3	Train Sleeper	718	541	1259
4	AC Bus	2319	14071	16390
5	Non AC Bus	820	0	820
6	Car	592	5277	5869
7	Taxi	994	16371	17365
8	Other	82	947	1029
Total		8135	66838	74973

From the above potential trips, the yearly tourist expected to shift to SilverLine is ~32,241 tourists considering international tourist and mode of travel AC train and Chair car. Bus as per the recent discussion with the K-Rail, it is brought to the notice that, the tourism statistics are actually duplicate in terms of the tourists are considered. Each location visited by a tourist is separately counted and there would be duplication. Based on the above analysis was done and found that per tourist, 2.7 was the factor arrived from the torusit survey. So, the tourists are considered as ~11,941 in the base year.

4.14.2 Demand Assessment for Operating Aggregator Services

This survey was organised near all the identified and proposed 26 Aggregator Stations such as Attingal, Kallambalam, Chathannur, Kundara/ Kottarakkara, Bharanikavu, Charummodu/ Mamoodu, Pandalam, Eraviperoor, Karukachal, Ettumanoor, Piravam, Chottanikara/Thrippunithura, Aluva, Nedumbassery Airport, Divine Nagar/ Chalakudy, Irinjalakkuda, Sobha City, Kunnamkulam, Edappal, Parappanangadi, Feroke, Koyilandy, Vadakara, Thalassery, Payyannur, Kanhangad.

The waiting time, existing mode of travel, access and dispersal mode to stations, travel time, travel cost and willingness to shift and pay were recorded from the commuters.

The main approach and steps followed to arrive at ridership to aggregators stations are as follows:-

a) Potential trips from rail, bus and taxi was identified. From rail, the potential passengers were arrived from UTS data, the commuters travelling by all class and with fare less than 45 per ticket was considered. From CRIS data, shorter distance trips was identified as potential trips which was observed to be negligible.
b) Potential trips from bus was estimated based on the travellers using fast passenger bus and 50% of the superfast passenger bus.
c) Car and taxi trips were based on generalised cost and with an average trip length of 15Km to 100Km.
d) Potential data and for rail, different options for potential trips were prepared based on fare as the data was mainly from source of UTS. Potential Passengers were selected four fare option, they are Option 1: between Rs. 15 & Rs. 45, Option 1: between Rs. 15 & Rs. 30, Option 1: between Rs. 30 & Rs. 45 and Option 4: fare less than Rs. 15.
e) Mode-wise percentage of shift is estimated from the aggregator survey and applied to the potential trips – Rail (65.1%), Bus (Non-Ac Bus – 25%) and Car & Taxi (5%).
f) The growth estimates considered were similar to growth rates adopted for realistic scenario.

The daily ridership for the four options are provided in the **Table 4-95** below:-

Table 4-95 Daily Ridership from Aggregator Services

Year	Ridership for Aggregator Services			
	Option 1	Option 2	Option 3	Option 4
2024	60834	48857	37144	33749
2028	71996	57891	44093	40095
2040	104080	83695	63753	57973
2051	126240	101528	77352	70348

From the above options, the daily ridership is varying from ~35,000 to ~60,000 in the commissioning year. As the ridership is comparatively lower against the capital and operating cost, the aggregator stations are proposed to be implemented later based on the future demand and not during the commissioning year.

4.14.3 Demand Assessment for Operating Sleeper Trains.

Option of providing night trains with sleeper class is also analysed. For this, traffic survey was conducted at major stations at both ends of the proposed alignment such as Thiruvananthapuram, Kollam, Chengannur, Kasaragod, Kannur and Kozhikode. The survey was also conducted at Kochi, as it is located at the centre.

The survey targeted the passengers travelling under reservation during the night time both by AC buses and Trains (mostly travelling by 1 AC/ 2 AC/ 3 AC) and the details related to the present trip of the passenger and their willingness to shift to Semi High Speed Sleeper Trains along with their willingness to use sleeper class was recorded.

The figure below provides the desired timings by respondents of arrival at destination station when started the journey at night.

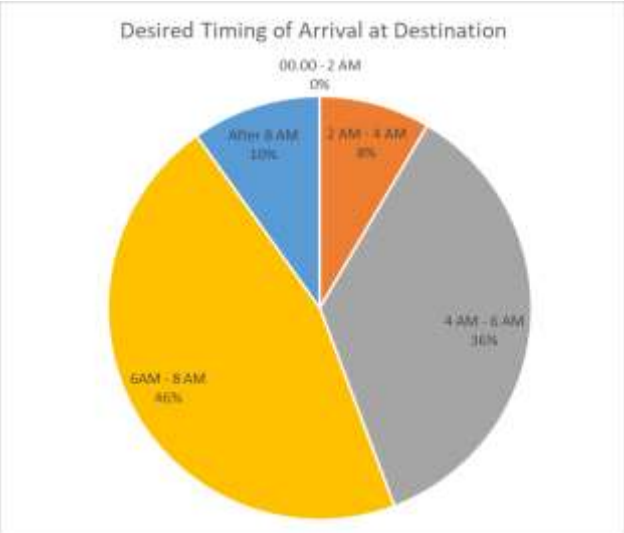


Figure 4-86 Desired Timing of Arrival by Passenger

From the above figure, it is observed that 56% of the passengers wishes to reach the destination station after 6AM and 36% wishes to arrive at destination between 4AM and 6AM.

It is also observed from the survey that the existing passengers travelling by sleeper class are weekly travellers. The details are provided in figure below:-

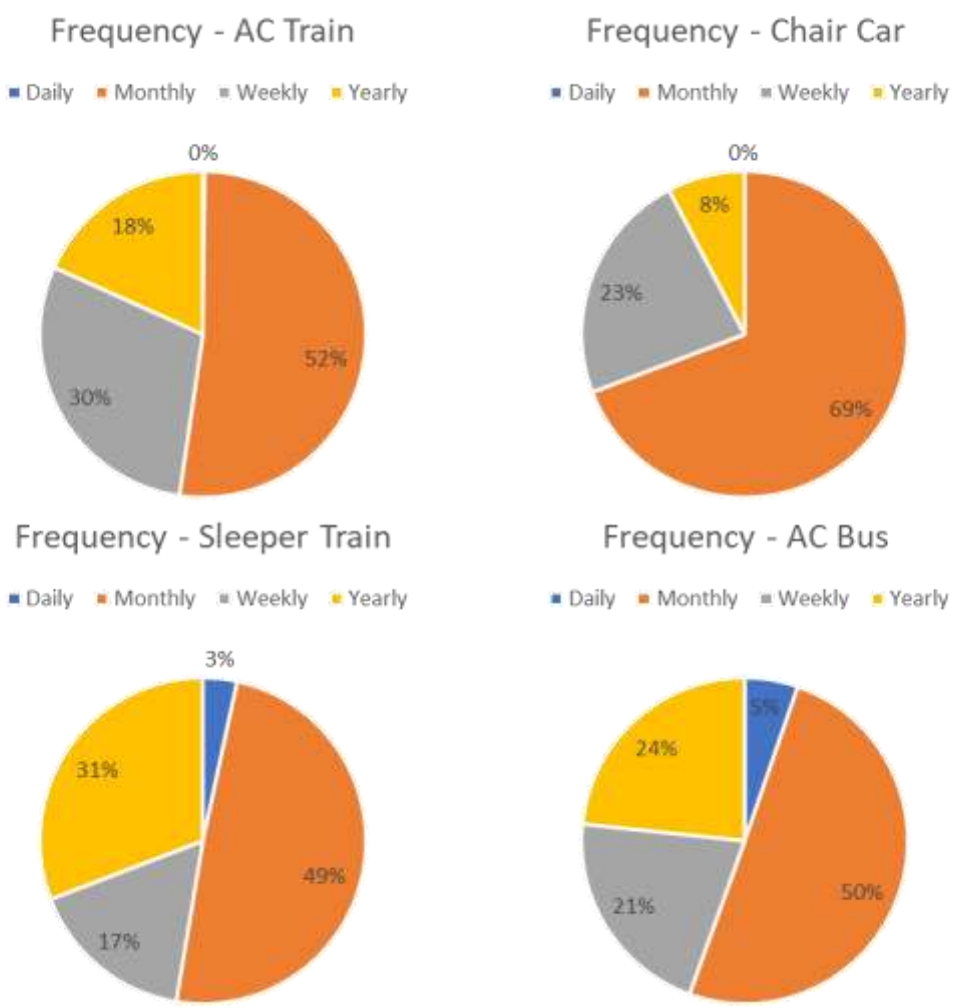


Figure 4-87 Desired Timing of Arrival by Passenger

The above figure clearly indicates that most of the sleeper class travellers are weekly and the likely trips for the SilverLine sleeper trains are provided in the **Table 4-96** below.

Table 4-96 Daily and weekly trips for sleeper trains

Sl. No.	Mode	Daily	Weekly
1	A C Train	0	192
2	CC	0	4
3	Train Sleeper	45	431
4	AC Bus	0	752
5	Non AC Bus	34	405
	Total	79	1785

From the above table, it is observed that on an average, daily trips expected in 255 passengers. So, sleeper trains only on weekends – Friday, Saturday and Sunday are only required if operated as daily expected daily patronage is low.

4.14.4 Demand Assessment for Operating Restaurant Cars

An option to introduce restaurant car within the trains are also analysed to understand whether restaurant cars to be added to the normal coaches. The objective is to provide, high-end Restaurant food to the passengers. The survey was conducted at major rail and bus stations such as Thiruvananthapuram, Kollam, Ernakulam, Kozhikode and Kannur.

The survey was conducted and covered the train passengers travelling by AC Classes. The data like present meal option during journey, issues with present mode, willingness of the passengers to shift to SilverLine and use of Restaurant Cars was recorded. The major results are provided in the **Table 4-96** below.

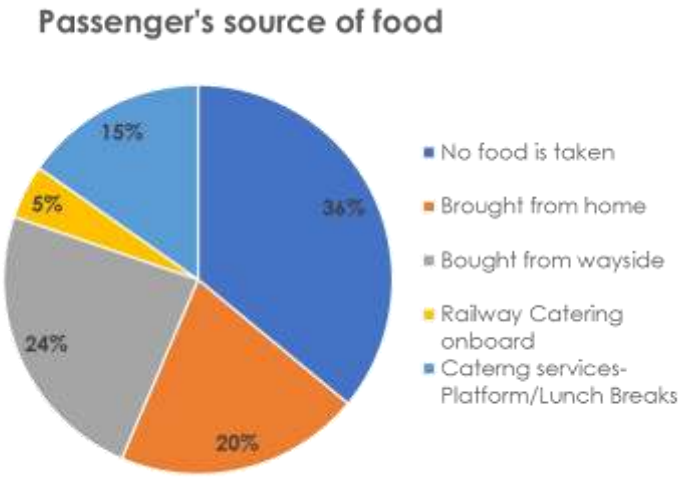


Figure 4-88 Passengers Source of Food during commuting

From the above figure, it is observed that the potential users constitute 44% as they take food from outside. The main reason for not taking food as Stated by the commuters (68%) during journey was due to the hygiene issues.

Potential trips and probable uses of restaurant cars are provided in the **Table 4-97** below:-

Table 4-97: Potential users for Restaurant cars

Sl. No.	Mode	Total
1	A C Train	90
2	Chair Car	2
3	Train Sleeper	505
4	AC Bus	1166
5	Non AC Bus	305
	Total	2067

The above figures are inclusive of weekly and daily travellers. So, on daily basis, probable users are expected to be ~295 passenger per day. To make the journey attractive to the SilverLine users, it is necessary to provide good quality and high-end restaurant type food through a reputed catering agencies, that will also increase the non-fare revenue.

4.15 CONCLUSION AND RECOMMENDATIONS

For all the future estimations, base year was considered as 2019-20, commissioning year as 2025-26 and horizon year as 2052-53. The traffic projection covers upto 50 year (2072-73) period for financial estimations. Elasticity approach (elasticity based econometric model) is used for future traffic forecasting which takes into account the elasticity of transport demand and probable pattern of future growth of the economy (regional - India and local - Kerala). The daily ridership was estimated for four different scenarios as Pessimistic, Business-As-usual, Realistic and Optimistic built-up based on variations in parameters such additional infrastructure developments, additional traffic generated, growth rates based on all India GDP and difference in mode-wise probability of shift from potential trips. The daily ridership was observed to be varying between approx. ~54,000 daily trips in worst scenario to ~1,14,000 trips in optimistic scenario in 2025-26. The realistic scenario is expected to generate approx. ~79,934 daily trips in 2025-26 (including trips from airports, feeder service and TOD). This when compared with the traffic study of high-speed rail from Thiruvananthapuram to Kasaragod done by M/s iMacS are provided below.

Table 4-98: Comparison between HSR and SilverLine

Project	HSR - Kerala	SilverLine
Year of Study	2016-17	2019-20
Catchment Population	3.3 Cr	3.3 Cr.
Length (Km)	540	529.45
Mode Choice	Multinomial Logit	Binary Logit
BY Ridership	85,332 (2020)	79,934 (2025)
HY Ridership	2,33,042 (2051)	1,58,946 (2052)
Feeder	Nil	6%
TOD	Nil	5%
Fare / Km	5	2.75

To improve the ridership during the operational years, following planning and policy interventions are recommended: -

a) Multi-modal integration: All SilverLine stations are recommended to be developed on multi-modal integration concept, in which users from silver-line, road, water, rail and other modes can interchange modes with ease, conflict free and faster transfer.
b) SilverLine to be part of mobility network: SilverLine is not to be treated as an independent transport system and should be integrated and shall form part of larger mobility network in Kerala involving, rail line, air, road, water and NMT networks. Within the network, SilverLine to be of highest hierarchy. Comprehensive mobility plans/regional mobility plans to be prepared in all districts in line with SilverLine. KMTA is formed for Thiruvananthapuram, Ernakulam and Kozhikode and this shall be the responsibility of the KMTA. The GoK is also taking

initiative to constitute a directorate for mobility. In case the directorate is formed, all the transport planning related activities shall be the responsibility of the directorate.

c) Provision of park and ride facilities at SilverLine stations. All stations shall be provided with ample parking facility and also with electric charging points. Discounts for park and ride shall be considered during the execution stage.
d) Provision of city feeders to provide accessibility from SilverLine stations to nearby city centres – Central Business Districts (CBD) and other catchments. The city feeder can be operated by the SPV or by STU (KSRTC) or by the private players. The only requirement is to have integrate timetable and ticketing for feeder and SilverLine.
e) Conducting periodic traffic surveys: traffic surveys including opinion surveys are to be conducted just before commissioning to re-establish the ridership estimates, fares and also every 3 years (minimum) during operational years. A detailed transport model can be prepared during the next stage and update it frequently based on any changes in the mobility pattern.
f) Provision of Travel discounts: group discounts, monthly pass, discount on return tickets etc., may also be considered for attracting more users. The discounts provided may be compensated by considering revenue from other non-fare revenue sources such as:-
    1) Property development
    2) TOD
    3) Revenue from lease of infrastructure – telecom towers (intelligent street poles), lease of Optical fibre, lease of utility duct for transporting oil, gas etc.
    4) Other commercial development.

DETAILED PROJECT REPORT

SEMI HIGH SPEED RAIL CORRIDOR
THIRUVANANTHAPURAM TO KASARAGOD

VOLUME II - MAIN REPORT
(PART A)

CHAPTER 5
BASIC PLANNING PARAMETERS

5 BASIC PLANNING PARAMETERS

5.1 GENERAL

The proposed new railway corridor with double lines in the State of Kerala from Thiruvananthapuram to Kasaragod is being planned as a Semi High Speed Railway (SILVERLINE) called “SilverLine”. Government of Kerala has taken approval of the Ministry of Railways to build this line as a Stand-alone Semi High Speed Rail line vide Railway Board’s letter No. 2018/Infra/12/33 dated 16.10.18.

Considering this project as a Stand-alone system, the project has been approved with System Parameters of Semi High Speed Rail with System Speed of 200 kmph, for a Running Time to cover the 529 kms long corridor having 11 number of stations in 4 hours on Standard Gauge based on directions from Govt of Kerala and the Railway board. Detailed reasons for adopting the above system parameters have been discussed in Chapter 2.

As Govt of India (Indian Railways) is yet to evolve detailed standards for such HSR or SHSR Lines, basic parameters followed in similar projects have been studied thoroughly and modified appropriately for the Kerala’s Semi High Speed Rail Corridor project. These are applicable for Standard Gauge(1435 mm) and for a system speed of 200 kmph, and the same are shown in the Table 5-1 below. These are based on the standards prevalent over the major railway systems in Europe, Japan, China and other countries. In consultation with K-Rail and other experts these parameters have been worked out for a reliable, economical and safe railway system which will meet the needs of the intra-state passengers effectively over the next half century or so. Specific discussions on some planning parameters are given in Civil engineering and other system chapters of this DPR. Guidance has been drawn from the following references for arriving at the Basic Planning Parameters given below.

(i) Railway Board’s letter No. 2018/Infra/12/33 dated 16.10.18
(ii) K-Rail’s letter no. P.4005/KRDCL/2018 dated 29.03.19
(iii) Track Alignment Design Parameters- Part 1 (European Standard, EU13803-1-June 2010)
(iv) Technical Memorandum: Alignment Standards for Shared Use Corridors TM 1.1.6
(v) Commission Regulation (EU) No. 1299/2014 for interoperability
(vi) Various discussions with K-Rail during the study period

Nevertheless basis of design parameters for the permanent civil structure and track has been adopted for higher speed up to 250 kmph forecasting the possibility of introduction of higher speed tilting train on a later stage.

Table 5-1: Basic Planning Parameters

Sl. No.	Parameters	Values
1	Design Speed for Passenger Trains	220 kmph
1 a	Maximum Permissible Speed (System speed or Operation speed or Commercial speed) for Passenger trains	200 kmph
1 b	Maximum Permissible Speed for Freight trains	120 kmph
2	Maximum Static Axle Load for design	25.0 tonnes (metric ton or t)
2 a	Maximum Axle Load for Passenger Coaching stock	16.0 tonnes
2 b	Maximum Axle Load for RORO	22.5 tonnes
3	Spacing of Tracks	4.5 m
4a	Maximum width of Rolling Stock	3.4 m
4b	Maximum height of Rolling Stock	4.5 m above Rail level
5	Gradients	
	5 a - Ruling Gradient	1 in 60 (Continuous steep grade to be limited to a length of 3 kms)
	5 b- Limiting Gradient	1 in 40 (Connecting ramp on non-running lines)
	5 c- Station Yards	Level for All Stations (except approaches to the non-running lines)
6	Turn-outs	1 in 18 for all the first passenger loops and for RO-RO cum Passenger loop at Kollam connecting the Depot. 1 in 9 for other loops and sidings including RORO.

Sl. No.	Parameters	Values
7	**Horizontal Curves**	
	7 a - Minimum Permissible Radius	1850 m (This permits an operating speed of 200 kmph though the design speed of 220 kmph requires minimum radius of 2250 m. For testing/ occasional train running international codes permit relaxation in curvature through acceleration levels permitted. However in future, raising of speed can be further considered with suitable adjustments of cant and cant deficiency if required)
	7 b - Limiting Radius for Station Approaches	650 m (Distance between centre line of Station & end of Curve is to be restricted to 2 Kms) (Exception at Thrissur due to ROB/ Land related issues)
	7c – Minimum Transition Length	Should ensure values not more than 2.25 mm/m for Cant gradient, 50 mm/s for rate of change of Cant and 55 mm/s for rate of change of Cant deficiency
	7d – Minimum length of circular curve or straight in between curves	100 m (Exceptions at a few locations due to land related issues but within Exception limits)
8	8 a - Maximum Cant	160mm
	8 b - Maximum Cant Deficiency	100mm (240mm required for Tilting Coaches for 250 kmph while introducing later)
	8 c- Maximum Cant Excess	100mm (To be re-verified when Goods trains are introduced based on stock)

Sl. No.	Parameters	Values
9	**Vertical Curves**	
	9 a- Desirable Radius	17,500 m (As proposed for SilverLine)
	9 b- Limiting Radius	10,000 m
	9 c- Minimum Length of Vertical curve or Inter distance between Vertical curves	100 m (Exceptions at a few locations due to land related issues but within Exception limits)
10	General Width of Formation	12.00 m
11	Right of Way considered for Permanent Land Acquisition	15 m for Viaduct 25 m for Cuttings and Cut & Cover 20 m for Embankment
12	Tunnel Cross-section Area	80.0 m^2 (Minimum width of Tunnel at 2000mm above rail level is 12000mm)
13	Desirable Minimum Gradient in Tunnels and Cuttings	1 in 400 (With summit vertical curve for good drainage)
14	Minimum Vertical Clearances at Structures	i. Above rail level to bottom of structure for New ROBs - 6450mm & Existing ROBs - 5800mm ii. Above rail level to bottom of structure for Cut & Cover - 6450mm iii. Above rail level to introdos of Tunnel - 8000mm at centre of tunnel profile and 7150mm at OHE location iv. Above road level to bottom of structure of NH/SH RUBs - 5500mm (as per IRC SP:84) v. Above road level to bottom of structure of Minor roads - 3500mm vi. Above Ground level to bottom of structure for Pedestrian - 2500mm

Sl. No.	Parameters	Values
15	Platform Length	410m for Class 'A' & 'B' Stations (For class' C' stations, it is to be considered at design stage)
16	Type of Traction	2x 25KV AC 50Htz
17	Type of Trains	EMU Train Set with 50% -75% Motoring Axle (approximately) for Passenger trains Loco hauled Freight trains
18	Type of Signalling & Train Control	ERTMS/ETCS Level-2 with LTE
19	Conicity in Rail & Wheel Profile	As per international standards
20	Static/Kinetic Rolling Stock Gauge and Structural Gauge	As per international standards for the proposed Rolling Stock dimensions

Note: For other planning parameters for other systems, please refer to the concerned System chapters.

5.2 TRACK AND LINE STRUCTURAL SYSTEMS

5.2.1 Alignment in Brief

Planning of the civil engineering system of the project is all about creating the various sustainable structural components like bridges, viaducts, embankments, track, yards and station buildings for the project. The purpose shall be to build these structures in the most efficient, safe, sustainable, and environment friendly way as possible. It is imperative that safety is to be ensured not only during the construction and the project execution stage but also during operation and continued use of the assets as well. Effort is made in this report to outline the requirement and the standards for ensuring the desired level of quality, serviceability and maintainability of the SHSR Structure with a perspective of maximising the return value of the money spent on the project. Effort is made in this report to make sure that these structures are made to cater to the desired serviceability, quality and maintainability and in general to obtain the return value of the money spent on the project.

Major part of the proposed corridor passes through green fields from Kochuveli, the first SilverLine station on the corridor in Thiruvananthapuram city to Ch:215350, about 2.0 km after the existing Chowara Railway Station. It runs parallel up to Angamaly Railway Station entirely on the right side of existing Railway line and crosses the existing Railway

track after the Kochi Airport and thereafter passes further through greenfields on the left hand side of existing Railway line and reaches the existing Thrissur Railway Station. Beyond Thrissur, the SilverLine is running parallel up to Pookunnam Railway Station and crosses the Thrissur - Guruvayur line at Ch:262650 and further continues on the left side parallel to existing Railway track through greenfields, joins at Tirur Railway Station and further continues parallel to the existing Railway track up to Kasaragod. In the stretches where this SilverLine is planned along and parallel to the existing railway tracks, the new railway track is planned in consultation with the Railways and K-Rail to be located at 7.80 m distance from the centre line of the first existing railway track to the centre of the first track of the SilverLine corridor.

Drawing at Figure 5-1 depicts a typical cross section of the planning of SILVERLINE tracks parallel to existing railway tracks.

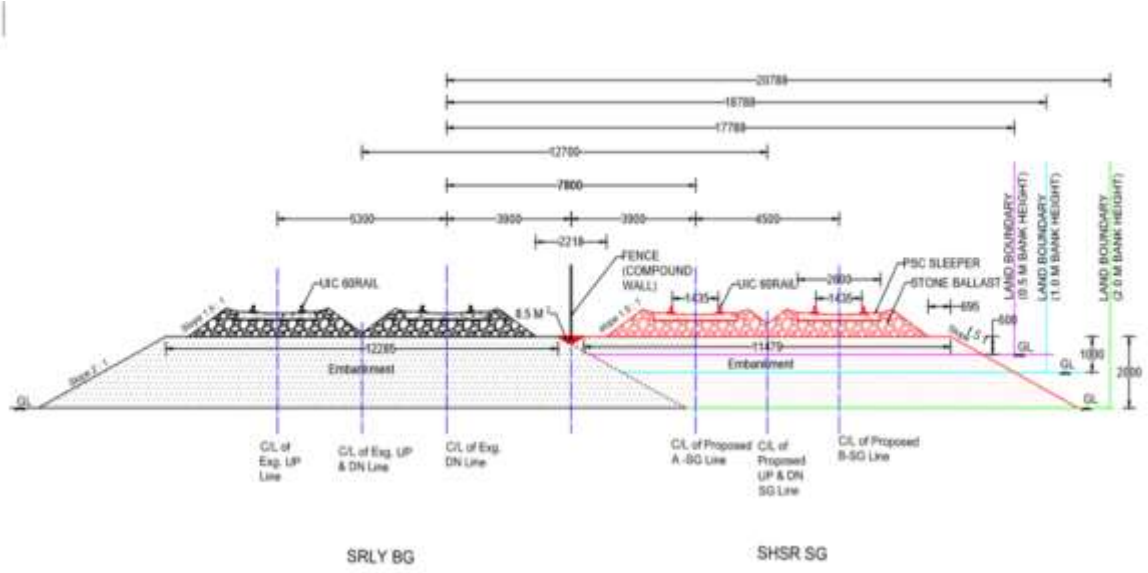


Figure 5-1: Typical CS showing SilverLine tracks parallel to existing railway tracks

5.2.2 Type of track structure: Ballasted and Ballastless track:-

Normally railway formation is made up of earthwork for which strict guidelines are available in RDSO documents and other international specifications. Formation made to these standards can carry trains at speeds at 160-200 kmph. This structure generally will be cheaper as it utilises locally available material mostly.

In view of the geological and climatic conditions of Kerala, the better choice may be elevated structure by constructing Viaducts throughout the entire length. Due to prolonged rainy season and intermittent rains throughout the year, At grade construction is likely to take more time. The time of construction for At-grade sections over formation and other allied works in Cutting, Cut & Fill and Banks will be substantially more. Construction of viaducts comparably is faster and hassle free. It does not require massive retaining walls, compound walls and other related works. The other advantage of viaduct is that it does not require any underpass, bridges, does not impose any hindrance to free movement and divide the land use. But to keep the cost of project to minimum, Viaduct

has been provided at unavoidable locations only, and at maximum stretches the alignment is kept over bank and cuttings.

A comparative Statement of Ballasted and Ballastless Track is given in Table 5-2.

Table 5-2: Comparison between Ballasted track and Ballast less track

S. No.	DESCRIPTION	BALLASTED TRACK	BALLASTLESS TRACK
1.	Maintenance Input.	Frequent maintenance & non-uniform degradation	Being fit & forget type, less maintenance for geometry.
2.	Cost Comparison	Relatively low construction costs but higher life cycle cost.	Relatively high construction cost, specially in Bank and Cutting sections but lower life cycle cost
3.	Elasticity.	High elasticity due to ballast.	Elasticity is achieved through use of rubber pads and other artificial materials.
4.	Riding Comfort.	Good riding comfort at speeds up to 250kmph.	Excellent riding comfort even at speeds greater than 250 kmph.
5.	Life expectation	Average Life expectation. (20-25 yrs) Average	Good Life Expectation of 50-60 years for base structure and 20-25 years for track structure
6.	Stability.	Adequately stable with the soffit, lateral and longitudinal ballast resistance. Standard and compacted ballast section with adequate shoulder and crib ballast to be ensured.	Stable with adequate lateral and longitudinal restraints offered by the fastening system.

S. No.	DESCRIPTION	BALLASTED TRACK	BALLASTLESS TRACK
7.	Churning up of Ballast.	Ballast can be churned up at high speeds, causing serious damage to rails and wheels.	No such damage to rails and wheels.
8.	Construction Depth.	Depth of Ballasted track is relatively high, and this has direct consequences for tunnel area.	Reduced height between 18 to 35 cm compared to Ballasted Track
9.	Maintenance possession	More possession time for routine maintenance	Less possession time but major repair will take substantial time
10	Suitability	Suitable for any length	Not Suitable for Short stretches
11	Maintenance Cost	More	Less
12	Maintenance time	Track needs to be closed for 3-4 hours for all types of periodical Maintenance with various Track Machines.	Less Maintenance
13	Need for Track Machine Sidings	Separate Track Machine Sidings for Stabling have to be constructed at extra cost	Not required
14	Need for Costly Track Machines Procurement.	Costlier Track Machines - Mostly Imported are to be Procured such as CSM, Unimate, BCM etc:	No Such Machineries are required for Maintenance
15	Construction Friendly	Easy & unskilled	Difficult & skilled construction
16	Design Criteria	Load on Sub structure and Superstructure will increase due to increase in dead load of Ballast	Comparatively less load

S. No.	DESCRIPTION	BALLASTED TRACK	BALLASTLESS TRACK
17	Minor corrections	Correction due to minor settlement of Formation/Cutting is possible with Track Machines	Not possible and heavy retrofitting at huge cost is required
18	Actual Cost	Usually less costly for the tracks provided with bank or cutting. (6.92 cr/km for double line approximately)	Relatively costlier compared to Ballasted track due to provision of plinth beam, sleeper pads and special fittings (9.20 cr/km for double line)
19	Cost & Time of restoration in case of Accidents	Low	Very High

Selection of the type of Tracks (Ballasted or Ballast-less track):-

The comparative statement furnished above depicts the merits and de-merits of the ballasted and ballastless track. Obviously the BLT has many advantages in respect to maintenance aspects inclusive of maintenance cost and overall possession/occupation of the track for maintenance etc. But with the advent and introduction of highly sophisticated modern track maintenance machine, the maintenance of ballasted track has become more simple and effective especially for the ballasted track laid on heavy flat bottomed PSC sleepers at uniform closer spacing.

Moreover, the retention of the track geometry is considerably longer with the deployment of the modern track machine and tampers for maintenance. Hence frequency of track tamping and track maintenance also has been considerably reduced. By proper planning and streamlining the maintenance operation, it is possible to optimise and reduce the overall track occupation time for maintenance. Moreover, there is also scope for cost reduction of the maintenance by adopting scientific, quality and planned maintenance practices for ballasted track. On the other hand, initial capital cost for installing the BLT track is high in comparison with the ballasted track. Besides the additional cost involved in designing and constructing the structures - especially the elevated structures to withstand the additional forces developed by rail structure interaction, also contribute to the escalation of the overall cost of the structure. Apparently the maintenance cost of the BLT is less. But rectification of track parameters is difficult in BLT in comparison with the ballasted track. Such rectification often necessitates in retro fixing of the anchor bolt etc of the fastening system/components of the fastenings. In case of BLT, for carrying out the

major repairs, complete demolishing and recasting of the track plinth/track slab becomes necessary sometimes which is extremely costly and may impediment the traffic badly.

Even though the overall life cycle cost of BLT and Ballasted track may be comparable with the marginal additional advantage for the BLT, the factors explained above favours Ballasted track for all normal sections except tunnels and viaducts.

5.2.3 Proposed Stations:

SilverLine has ten main stations and one halt station in the entire length of about 529.45 kms length. The names and location of these stations are given in Table 5-3 below.

Table 5-3: List of Main Stations

S.NO	STATION NAME	CLASS	CHAINAGE
1	THIRUVANANTHAPURAM	A	0
2	KOLLAM	A	55338
3	CHENGANNUR	B	102900
4	KOTTAYAM	B	136108
5	ERNAKULAM	A	195329
6	KOCHI INTERNATIONAL AIRPORT	C	212318
7	THRISSUR	A	259117
8	TIRUR	B	320562
9	KOZHIKODE	A	357868
10	KANNUR	A	446095
11	KASARAGOD	A	529450

Table 5-4: List of Minor or Aggregator Stations – (in future based on traffic)

S.No.	Name of Minor or Aggregator Station	Between Main Stations	Chainage
1	Thiruvananthapuram Airport	Thiruvananthapuram city - Kochuveli	-4.3

5.2.3.1 Classification or type of proposed stations: -

- Based on Status: - Thiruvananthapuram, Kollam, Ernakulam, Thrissur, Kozhikode, Kannur and Kasaragod stations are the Class 'A' stations, 7 in number. Out of these, 6 stations are situated in Municipal Corporations (except Kasaragod) and hence classified as Class 'A' stations. Kasaragod is classified in 'A' category being a terminal Station. Chengannur, Kottayam and Tirur stations are classified as 'B'. Kochi International Airport is class 'C' station. Thiruvananthapuram air-port station will also come in 'C' class station whenever taken up. While the Thiruvananthapuram, Ernakulam and Thrissur stations are on viaducts, Kozhikode station is underground and balance stations are on at Grade.
- Based on type of Traffic:- Thiruvananthapuram, Ernakulam ,Thrissur and Kasaragod stations being passenger train originating stations, three loops with two island platforms are provided for either direction for movement. In addition, two RORO loops with one loading line with 10m wide platforms are also provided at these Stations at nearby locations for want of space in these Stations. At Kollam also three loops are provided with two island platforms and one RORO Loop on either directions with one RORO loading line with 10m wide platform being induction and withdrawal station with Depot facility. All other stations are provided with one passenger loop and one island platform on either side. In addition one RORO loop is provided on either side at Chengannur, Kottayam and Tirur and one RORO loop on either side for Kozhikode at West Hill , and for Kannur at about 1 Km away for want of space at these stations. Even though, Kozhikode also is a passenger train originating station, extra loops are not provided as the available space doesn't permit and these loops are provided at West hill location.

Design parameters of track and other structural systems such as viaducts, tunnels, embankments, cuttings are discussed in Chapter 8.

5.3 ROLLING STOCK

Rolling Stock is an important asset and proper planning is required in selecting its right type and design. We have examined the different types of rolling stock that can be used on the SilverLine Corridor, their advantages, disadvantages and suitability for the type of service needed and have determined the most suitable stock. In deciding the type of rolling stock, consideration given to the operational requirements, interface with

infrastructure, whole life cost, as well as the client's aspirations and the compatibility of the rolling stock with that of other HSR corridors.

EMU (Electric Multiple Unit) trains, with driving facilities on both end of the train, are recommended for using in Thiruvananthapuram- Kasaragod Corridor because of the inherent advantages like the better operating parameters and travel time, faster acceleration and deceleration, better adhesion, reduced axle load, more suited for regenerative braking, higher energy efficiency etc. In addition, it will enable full use of the floor area of a train for passengers, and thus increase the transportation efficiency. This also has the effect of minimizing the design load for construction if EMU for this SilverLine are chosen. Moreover, this choice would allow a cost reduction in the system.

Based on the traffic demand forecasted, it is proposed to begin the initial commercial services with train set of a 9 (nine) car configuration, which consists of six motor cars and three trailer cars. Train length is to be increased up to 12/15 cars from the year 2029 onwards to meet the PHPDT demand by augmentation of suitable multiples of additional motor cars and trailer cars. Approximate Passenger capacity of around 675 for 9-car train length has been considered. Space must be earmarked for service area, pantry, luggage, toilets etc. in each car, thereby reduction in paid area per car. Also, with multiple classes of travel being offered in the train services, the total passenger capacity gets limited because of 2+2 seat and 3+2 seat configuration.

Technological parameters which are prevailing in the latest semi high speed trains are proposed for the Rolling Stock to run in Thiruvananthapuram - Kasaragod Corridor. Aluminum alloy-based car body is proposed for the Rolling Stock. Each car will have two bogies (Bo-Bo configuration) with primary and secondary suspensions. The interior will have modern state of art design to provide at most comfort to the passenger with luggage racks, toilet and reclining and rotating seats. Facilities for persons with reduced mobility is also proposed in the detailed project report.

The propulsion system is VVVF based with asynchronous motors/PMSM. The brake system proposed is blended braking system with predominate usage of regenerative brake system and supplementary usage of pneumatic brake system. The pneumatic brake system may be disc/tread or mixture of disc and tread. Two door per side of each car is proposed for the train. These doors will function as emergency doors during the emergency evacuation. For maintaining the inside temperature of the saloon and cab, roof mounted HVAC is proposed. Modern type of communication system and entertainment system will be available in the Rolling Stock which is used in emergency conditions also.

5.3.1 The basic planning (design) parameters of Rolling Stock

The basic planning parameters of Passenger Rolling Stock and RORO Rolling Stock are listed below:

Passenger Rolling Stock:

Track Gauge	:	1435 mm
Type of Train	:	EMU train set
Maximum design speed	:	220 kmph
Maximum operation speed	:	200 kmph
Numbers of cars per train	:	9 extendable to 12/15 in future
Car body width	:	3400mm (maximum)
Car body height above Rail Level		4500mm
Car body material	:	Aluminium
Power System	:	2 x 25 kV AC
Braking system	:	Regenerative brake, Electric/ Pneumatic brake blending
Emergency braking distance	:	<1300m
Traction circuit and configuration	:	VVVF inverter control using IGBT and asynchronous traction motor/PMSM
Seating arrangement	:	2+2 Business class 3+2 Standard class

RORO Rolling Stock: Trains with 2 Locos and 40 wagons.

Operational Speed	:	120 kmph
Axle Load	:	22.5 Tonnes
Maximum Width	:	3200mm

Maximum Truck loaded Height above Rail Level : 4500 mm

Wagon Length : 15 m

5.4 POWER SUPPLY AND TRACTION

5.4.1 Un-interrupted electric power supply

Un-interrupted electric power supply is essential for a Semi High Speed Rail system for running trains, Operation Control Centre, tunnel ventilation, station services (lighting, air-conditioning, firefighting & alarm system, lifts and escalators, Signaling & Telecommunications), Depot services (Inspection Shed, Workshop and Pit, wheel lathe etc.) and other maintenance infrastructure. EHV supply at the voltage level of 220/110 kV may be obtained from the Kerala State Electricity Board Ltd (KSEBL) to the various Receiving/Traction Substations for train operation and a separate 33kV/ 11kV supply is to be obtained from KSEBL, for the operation of auxiliary systems at Stations and Depot.

As per the design parameters specified, the system is designed for running the train at a speed of 220 kmph and can go up to 250 kmph. The power supply and OCS system is designed to cater to the speed of 250kmph keeping future in view.

5.4.2 AC Traction power supply systems in use for HSR

Worldwide, 25 kV AC supply is adopted for operating the HSR lines except Germany (where the Supply system is in 15 kV , 16 2/3 Hz). The 2x25 kV traction feeding system has been used for the operation of HSL lines of Japan, France, Taiwan, South Korea, China, Spain, Italy, and India.

5.4.2.1 Latest developments in India:-

Indian Railways (IR) commenced revenue services by using 25kV AC feeding system. In 1986, when the freight and passenger traffic in some of the electrified sections reached very high levels, IR commissioned a special study of 2x25 kV system of electrification for adoption on high traffic non-electrified routes because the system was already well established by then, and found eminently suitable for electrification of sections with heavy freight trains and/or high-speed passenger trains.

IR decided to implement a pilot project on 2 x 25 kV Autotransformer feeding system on Bina-Katni-Annupur-Bishrampur-Chirimiri section and is in operation over the last 20 years.

Indian Railway has also implemented the 2x25 kV feeding system on its planned dedicated freight corridors [eastern and western corridors]

National High-Speed Rail Corporation Limited (NHSRCL) is implementing the project of high-speed train corridor between Mumbai and Ahmedabad with 2x25 kV Auto

transformer (AT) type feeding system as per the Joint feasibility report prepared by M/s Japan International Consultants.

Hence, after detailed study and analysis, considering the advantages of 2x25 kV system and acceptance of 2x25kV feeding system for High-Speed Rail operation in internationally and in India, 2x25 kV, AT feeding traction system is adopted for the proposed Thiruvananthapuram – Kasaragod Semi High Speed Corridor.

5.4.2.2 2x25 KV Traction System for SilverLine Corridor

Points considered while selection of Receiving /Traction Substation:

(i) Norms for locating the Traction substations based on the capacity of Transformer and Voltage regulation during normal condition as well as feed extension in case of emergency
(ii) Capacity of Traction transformer is decided to feed the normal as well as emergency conditions (feed extension). It will ensure the normal working condition of running train services with specified load and speed
(iii) Availability of Grid substation (GSS)/KSEBL in nearby location of the alignment
(iv) Traction substations shall be approachable by road and preferably by railway for better connectivity of rail and road

To achieve the desired reliability and operational requirements, 8 numbers of Traction substations 220kV / 110kV / 2x25kV are provided in this corridor. This will enable to feed 2x 25 kV traction supply to the corridor with a maximum speed of 250 kmph at specified load.

The details of the proposed grid substations and Traction substation is given in **Table 5-5**:

Table 5-5: Proposed location of Grid substation and Traction Sub-Station

Sr No	Location of Grid Substation	Location of Traction Substation
1	220 kV Substation ,Pothencode	Kazhakootam
2	220 kV Substation , Kundara	Kundara
3	220 kV Substation , Kottayam	Kottayam
4	110 kV Substation , Angamali	Angamali
5	220 kV Substation , Kunnamkulam	Kunnamkulam
6	110 kV Substation , Chevayur	Chevayur
7	110 kV Substation , Chova	Chova
8	220 kV Substation , Ambalathara	Ambalathara

The traction supply system will be as follows:

(i) There will be a spacing of 70 to 100 km between the Traction Substations (TSS)
(ii) The distance between Sectioning and paralleling post (SP) and traction substation (TSS) will be approximately 35 - 50 km and Sub sectioning and paralleling post (SSP)will be placed in between SP and TSS.
(iii) There will be autotransformer feeding at regular intervals
(iv) Overhead Contact system used for delivering the power to Rolling Stock

5.4.2.3 Types of catenary system:

There are 3 types of the catenary system adopted for mainline railways and High-Speed railways

- Simple catenary system
- Simple catenary with stitch wire system (Y- stitch)
- Compound catenary system

SilverLine corridor is designed to cater the speed of 250 kmph with specified load. After detailed analysis, considering the saving in construction cost, easy maintainability, reliability and international practice for adopting simple catenary system for HSR operations, simple catenary type OCS system is proposed.

The **Table 5-6** shows the details of the proposed system of this project:

Table 5-6: Proposed OCS system

Item	Main line
Type of overhead equipment	Simple catenary
Catenary wire	120 mm^2, Cu alloy
Contact wire	150 mm^2, Cu alloy
Negative feeder	288 mm^2, Aluminium

5.4.2.4 Electrical Clearances

The electrical clearance shall be followed as per the EN 50119 and the kinematic gauge shall be as per UIC 606 standards. As per EN -50119 in 25kV ac traction, the recommended air clearance between earth and live parts of the overhead contact system are

Static conditions - 270 mm

Dynamic conditions - 150 mm

The recommendation provided in EN - 50119 for adjacent live ac contact line of differing voltage phases are

Static conditions - 540 mm

Dynamic conditions - 300 mm

5.4.2.5 SCADA system

The SCADA system is provided at Operation Control Center (OCC) to monitor and control the traction supply

5.4.2.6 Power requirement

Power requirement and energy consumption for the years from 2025 to 2052, considering the traffic level projected and the train operation plan is given in Table 5-7.

Table 5-7: Power demand and energy consumption

Year	Total Energy Consumption (Traction and auxiliary) in million unit	Power Demand (MVA)
2025-2026	279	104
2032-2033	321	119
2042-2043	427	158
2052-2053	497	184

5.4.2.7 Green Energy

It is planned to use 100 percentage of power from renewable sources like solar by in-house production and purchase of renewable power from KSEBL and other renewable supply company to make the project as a green and Sustainable Transport System

5.5 SIGNALLING & TRAIN CONTROL AND COMMUNICATION SYSTEM

5.5.1 Signalling & Train Control System

The Signalling and Train Control System shall provide the highest security level by means of an efficient Train Control, ensuring safety in train movements. It assists in optimization of rail infrastructure investment and running of efficient train services on the network.

5.5.1.1 Train operation Management

Thiruvananthapuram -Kasaragod – SilverLine Corridor is to be equipped with ERTMS/ETCS level 2 (European Train Control System) that will provide integrated, efficient, standardized, proven and off-the-shelf world class electronic interlocking, Signalling and Traffic Control Systems.

SilverLine operation requires efficient and proactive train operation management. The ERTMS/ETCS level-2 -Train control management System (TCMS) will provide the operator with an integrated and centralized control system that will ease the management of train operation on the SilverLine - Line and interface with depots especially in case of degraded and emergency situations. The ERTMS/ETCS level 2 cab signalling will ensure

safe and efficient bi-directional train operation for both revenue and non-revenue trains during both revenue operation time (ROT) and maintenance working time (MWT), improving the work train movement safety and the MWT efficiency. The ERTMS Train control management System (TCMS) will provide real time supervision, monitoring and control functions on the complete SilverLine and will allow proactive control from the OCC (or back-up OCC).

The LTE/GSM-R is radio system for providing voice and data communication between the track and the train, based on standard LTE/GSM and it uses frequencies specifically reserved for rail application with certain specific and advanced functions. Global System for Mobile Communications (GSM-R) (2G) technically has limited capabilities compared to fourth generation (4G) broad-band systems that offer higher data rates, e.g., long-term evolution (LTE). It is thus relevant for HSR to replace the current GSM-railway (GSM-R) technology with the next-generations railway-dedicated communication system, which provides improved capacity and capability in future. As GSM-R is based on public GSM standard, the same constraints on technical life cycle apply, so that GSM-R support is expected up to year 2030 at least (according to the official information provided by GSM-R suppliers)

The Detailed Project Report provides the main design of Signalling and Train Control system for operation of the line with design speed 220 upgradable to 250 Kmph, as also the associated sub system like Power supply, Surveillance system for monitoring and safety etc. In order to comply with requirements of such high-speed rail corridor, the system ERTMS/ETCS Level -2 with LTE system is proposed.

LTE based ETCS Level-2 signalling system is still on trial in some railways in the world. LTE based ETCS -Signalling Train control System has not come to full-fledged proven certified system. If LTE System does not mature and fully accepted worldwide, by the time this corridor work is executed, GSM-R can be considered instead of LTE. ERTMS/ETCS Level-2 with GSM-R can be adopted at the time of executing this project.

Global System for Mobile Communications (GSM) with limited capabilities, to fourth-generation (4G) broad-band systems that offer higher data rates, long-term evolution (LTE). It is thus relevant for HSR to replace the current GSM-railway (GSM-R) technology with the next-generation railway-dedicated communication system providing improved capacity and capability.

5.5.1.2 The basic Signalling & Train Control (ERTMS/ETCS level-2) sub-systems

(i) ETCS level-2 (European Train Control System)
(ii) LTE-Mobile Communication System for Voice & Data
(iii) Interlocking System (EI/CBI)
(iv) Electric Point Machine
(v) Track Vacancy Detection system (Axle counter)
(vi) Automatic Train Supervision (ATS)
(vii) Operation Control Centre (OCC) with backup BCC

(viii) Fall-Back Block System (with Line Side Signals)

5.5.2 Communication System

The communication system is backbone for Signalling & Train Control system, SCADA system, Automatic Ticketing system, Safety & Security system, etc. and provides communication service for information to passenger, Administrative management, Operation & maintenance, Emergency control etc. requirements of a high-speed train network.

5.5.2.1 The Communication facilities proposed for meeting the requirements

(i) Supplementing the Signalling system for efficient train operation.
(ii) Exchange of managerial information
(iii) Crisis management during emergencies
(iv) Passenger information system

The LTE/GSM-R a radio system for providing voice and data communication between the track and the train, based on standard LTE/GSM and using frequencies specifically reserved for rail application with certain specific and advanced functions. Global System for Mobile Communications (GSM-R) (2G) technically has with limited capabilities compared to fourth generation (4G) broad-band systems that offer higher data rates, e.g., long-term evolution (LTE). It is thus relevant for HSR to replace the current GSM-railway (GSM-R) technology with the next-generations railway-dedicated communication system, which provides improved capacity and capability in future. As GSM-R is based on public GSM standard, the same constraints on technical life cycle apply, so that GSM-R support is expected up to year 2030 at least (according to the official information provided by GSM-R suppliers).

Long Term Evolution (LTE) wireless communications has been picked by the leading professional mobile radio standardization bodies as the technology of choice to support mission-critical voice and broadband services in the future. The ability of LTE to support advanced broadband applications is set to help public safety and railway organizations to operate more efficiently. Nevertheless, meeting the consumer demand for on train broadband services, while supporting extremely high bandwidth consuming applications such as on train Closed Circuit Television (CCTV) surveillance, is still a major challenge that require a closer look before planning and dimensioning the LTE network. LTE based ETCS Level-2 signalling system is still on trial in some railways in the world. LTE based ETCS -Signalling Train control System has not come to full-fledged proven certified system. If LTE System does not mature and fully accepted worldwide, by the time this corridor work is executed, GSM-R can be considered instead of LTE.

The reliable Digital Train Radio system and fibre optic-based data transmission backbone should be considered for safe and reliable operation of Semi High Speed Rail Line. A data transmission network shall be provided to serve the OCC, back-up OCC, maintenance bases offices, stations, tunnels depots and other line side locations.

5.5.2.2 The basic communication sub-systems

(i) LTE System for Voice & Data (with Radio System and Trainbone equipments)
(ii) Backbone Transmission Network (with SDH & GbEN)
(iii) Telephone system (IP PBX exchange system)
(iv) Centralised Digital Recording System (CDRS)
(v) Passenger Address System (PAS)
(vi) Passenger Information and Display System (PIDS)
(vii) Time Distribution System with GPS system
(viii) Closed Circuit Television System (CCTV)
(ix) Facility -Supervisory Control and Data Acquisition (F-SCADA)

5.6 TICKETING & FARE COLLECTION SYSTEM

5.6.1 High Speed railways are expected to be used more often by people who try to use their time effectively than in the existing railways where much time is taken for travel. Such businesspeople tend to use the online system for reservation, rather than waiting in line at ticket windows, so a need for internet reservation is probably greater for Semi High Speed Railways than for existing railways.

Semi High Speed Railway Transportation system is expected to handle a large volume of passengers. The Ticketing System handles reservation, ticket Issuing and Inspection processes. The ticketing System shall provide world class ticketing facility to the passenger. After booking the ticket either by online / offline, reservation and ticket issuing are processed in a sequence by central ticketing system server. Passenger's tickets are checked to confirm their validity during inspection process. Inspection of tickets is conducted at the time of both entering/ exiting the concourse, or on board.

All the data used in ticketing process system is stored in database of centralised ticketing system server. Centralized ticketing server is connected through via backbone transmission network (BTN) with application servers. After completion of ticketing process, centralized server shall communicate the transaction result to application server. The system shall ensure the ability to obtain complete and clear data backup and recovery of operation process. Central computer system shall be in redundant configuration and located at OCC and BCC.

5.6.2 The basic ticketing and fare collection sub-systems are listed below:

- Centralized Computer Ticketing System
- Station Computer System
- Cash Handling equipment's
- Automatic Gate with card reader
- Ticket Vending Machine (TVM)
- Ticket office Machine (TOM)
- Mobile Ticket Machine
- Portable Processing unit (PPU)

- Mobile ticketing (Scanner & Printer)

5.7 ROLLING STOCK DEPOT

5.7.1 Rolling Stock Depots

Rolling Stock Depots are required to maintain the Rolling Stock for providing a reliable and available service to the passengers. A depot should contain the desired range of facilities and assets to meet the operational requirements of the maintenance assets that are appropriate for the range of rail vehicles that are to be serviced there. It shall be located to provide ease of access for maintenance and management personnel and contain modern welfare facilities that create a safe environment for efficient operation. Accordingly, the depot facilities include workshops for the maintenance, the storage of tools and equipment required by employees assigned to the maintenance of each system or infrastructure, storage space for the vehicles used for maintenance and space for the maintenance of these vehicles.

5.7.2 Effective depots are designed to carry out specific tasks which are aligned with a train service operation plan. Depots carry out several activities, some examples of which are:

- Stabling.
- Waste tank emptying.
- Watering / tanking.
- Train wash.
- Sand box replenishment.
- Inspection and assessment (manual or automatic).
- Wheel re-profiling.
- Light maintenance activities.
- Heavy maintenance activities.
- Major overhauls.
- Bogie refurbishment.
- Interior cleaning.
- Underframe cleaning and bio-hazard management.
- Bespoke equipment maintenance (for example, HVAC systems).

5.7.3 After various deliberations, it is proposed to provide Depots at Kollam and Kasaragod for the SilverLine corridor. The Depot at Kollam will have full-fledged facilities to maintain and refurbish the Rolling Stock. The Depot at Kasaragod will have minimum maintenance facilities for inspection and stabling the Rolling Stock. The Depot will be equipped with various facilities such as stabling lines, inspection bay lines, workshop bay lines, wheel lathe plant etc. and machinery and plants such as pit jacks, bogie maintaining equipment etc. The services offered by two depots is classified as per Table 5-8.

Table 5-8: Services Offered by Two Depots

Station	Function		Inspection Classification			
	Depot	Workshop	General Inspection	Bogie Inspection	Daily and Regular inspection	Unscheduled maintenance
Kollam Depot	•	•	•	•	•	•
Kasaragod Depot	•				•	•

Stabling lines are proposed at both Kollam and Kasaragod Depot and some stabling lines are proposed in mainline for operation purpose. Inspection bay lines are available at both Kollam and Kasaragod Depot. Workshop lines are provided only at Kollam Depot which will facilitate all the overhauling and refurbishment of the Rolling Stock.

KERALA RAIL DEVELOPMENT CORPORATION LTD.
5th Floor, Trans Towers, Vazhuthacaud, Thycaud P.O.
Thiruvananthapuram, Kerala - 695 014
Phone: 0471-2324330, 2326330 Fax: 0471 2325330
krdclgok@gmail.com | www.keralarail.com, www.krdcl.co.in


fb.com/OfficialKRail


krail


OfficialKRail


OfficialKRail


OfficialKRail


94468 79687